



This is a digital copy of a book that was preserved for generations on library shelves before it was carefully scanned by Google as part of a project to make the world's books discoverable online.

It has survived long enough for the copyright to expire and the book to enter the public domain. A public domain book is one that was never subject to copyright or whose legal copyright term has expired. Whether a book is in the public domain may vary country to country. Public domain books are our gateways to the past, representing a wealth of history, culture and knowledge that's often difficult to discover.

Marks, notations and other marginalia present in the original volume will appear in this file - a reminder of this book's long journey from the publisher to a library and finally to you.

Usage guidelines

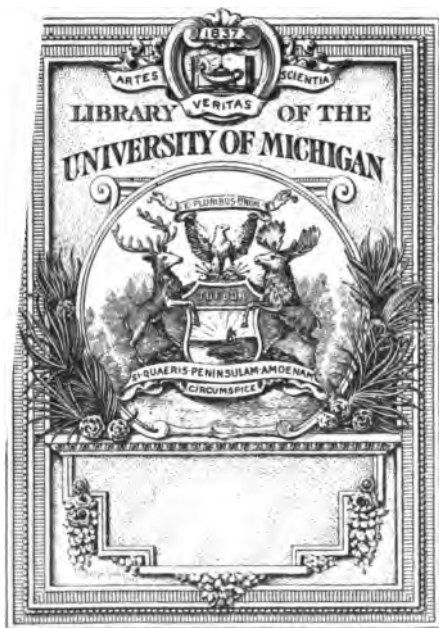
Google is proud to partner with libraries to digitize public domain materials and make them widely accessible. Public domain books belong to the public and we are merely their custodians. Nevertheless, this work is expensive, so in order to keep providing this resource, we have taken steps to prevent abuse by commercial parties, including placing technical restrictions on automated querying.

We also ask that you:

- + *Make non-commercial use of the files* We designed Google Book Search for use by individuals, and we request that you use these files for personal, non-commercial purposes.
- + *Refrain from automated querying* Do not send automated queries of any sort to Google's system: If you are conducting research on machine translation, optical character recognition or other areas where access to a large amount of text is helpful, please contact us. We encourage the use of public domain materials for these purposes and may be able to help.
- + *Maintain attribution* The Google "watermark" you see on each file is essential for informing people about this project and helping them find additional materials through Google Book Search. Please do not remove it.
- + *Keep it legal* Whatever your use, remember that you are responsible for ensuring that what you are doing is legal. Do not assume that just because we believe a book is in the public domain for users in the United States, that the work is also in the public domain for users in other countries. Whether a book is still in copyright varies from country to country, and we can't offer guidance on whether any specific use of any specific book is allowed. Please do not assume that a book's appearance in Google Book Search means it can be used in any manner anywhere in the world. Copyright infringement liability can be quite severe.

About Google Book Search

Google's mission is to organize the world's information and to make it universally accessible and useful. Google Book Search helps readers discover the world's books while helping authors and publishers reach new audiences. You can search through the full text of this book on the web at <http://books.google.com/>



S

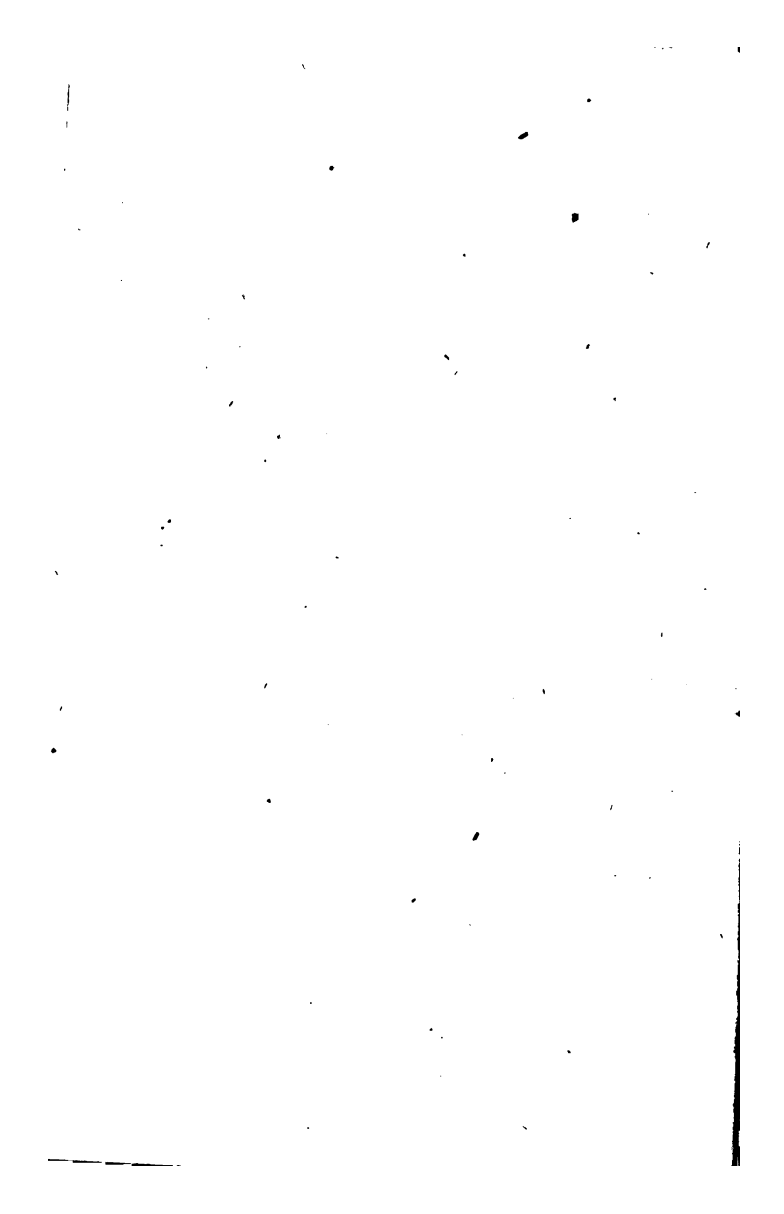
499

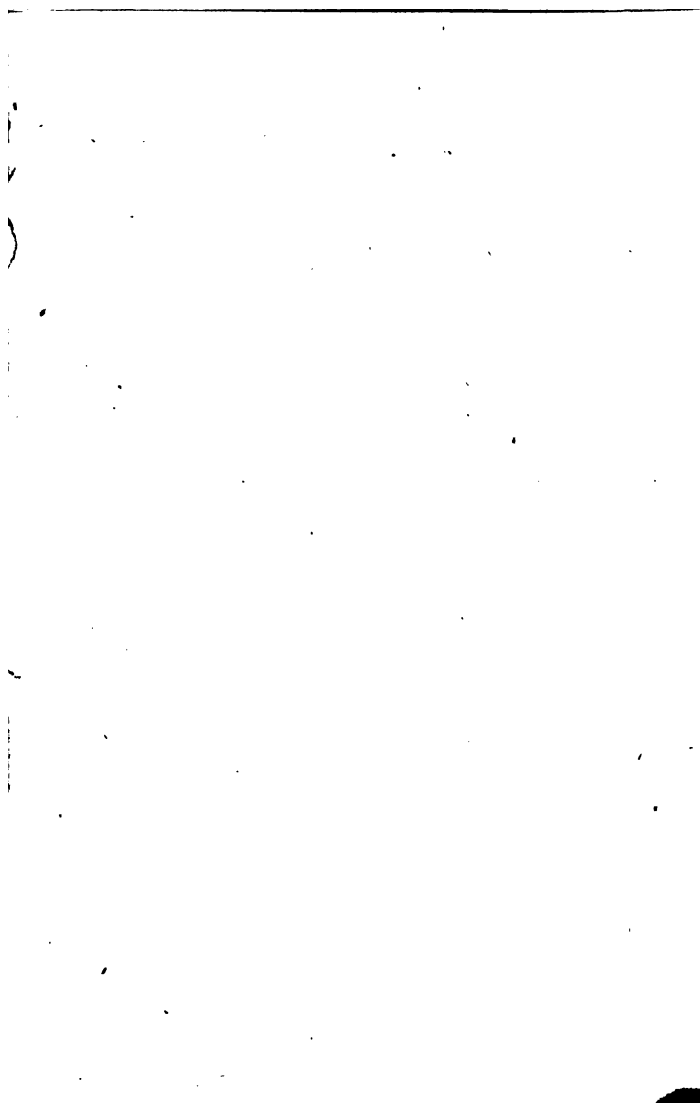
,B93

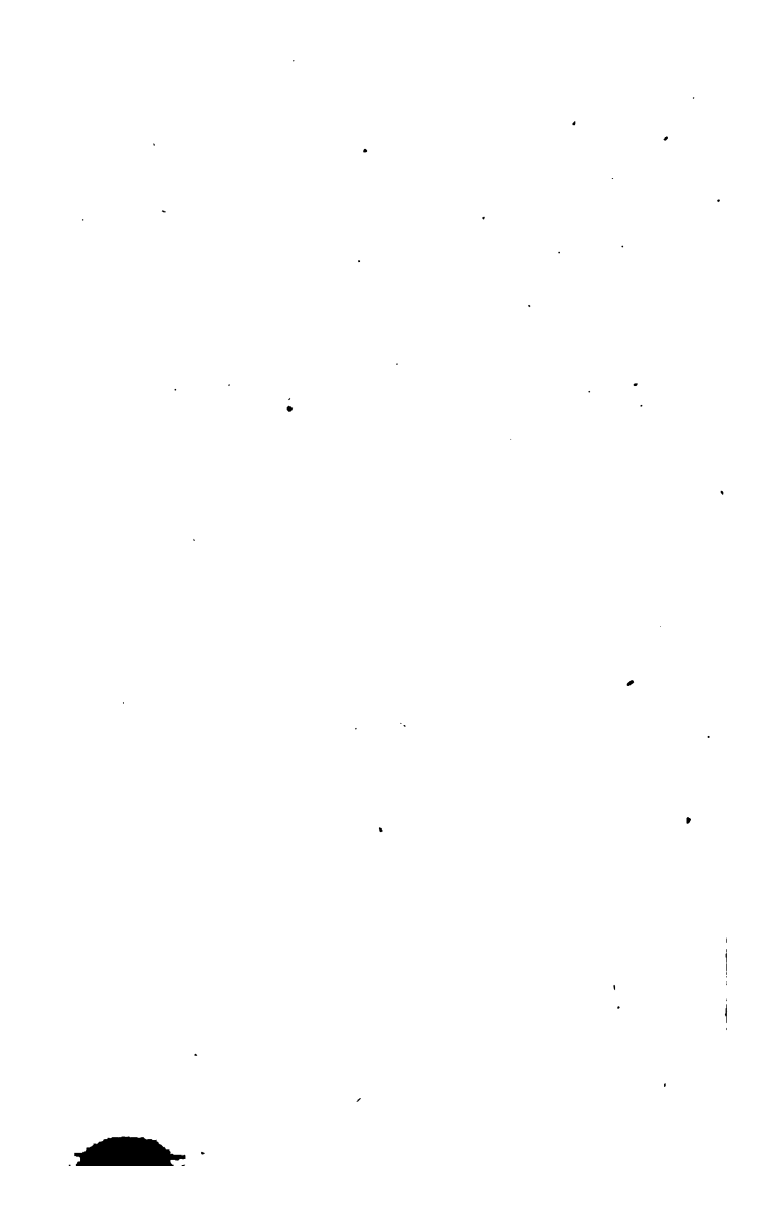
184-

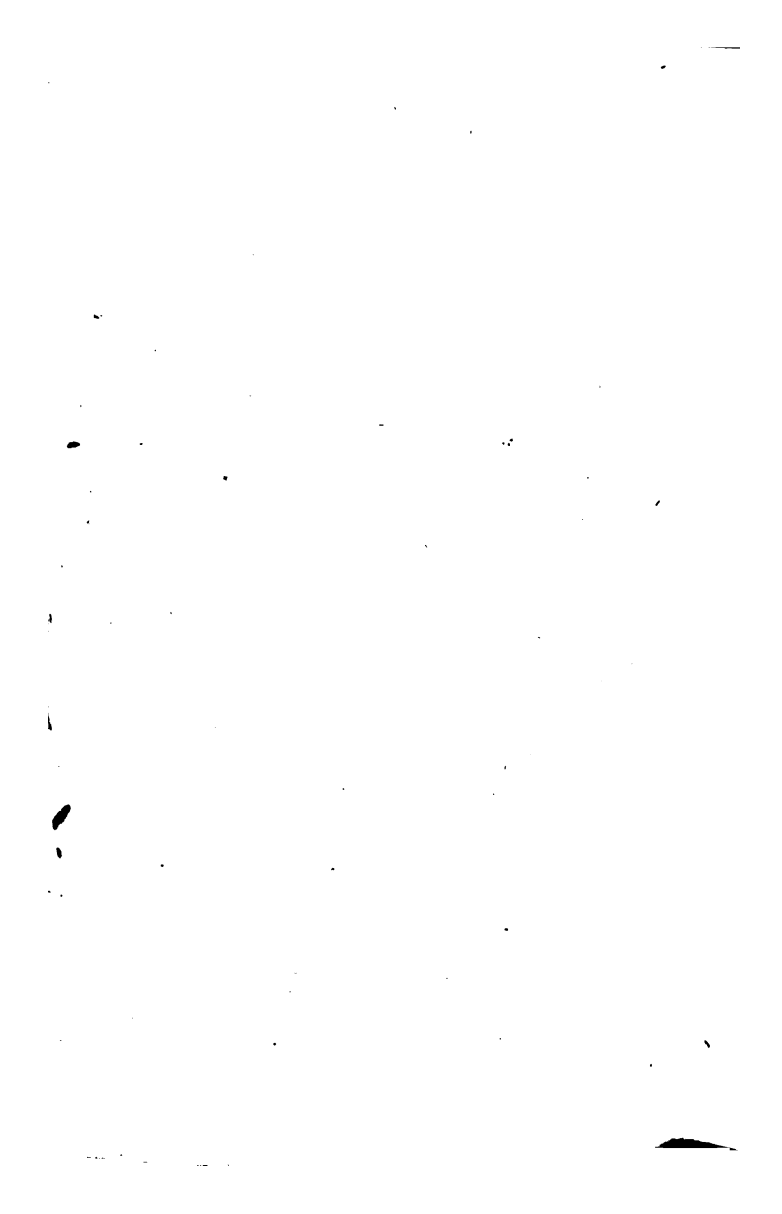


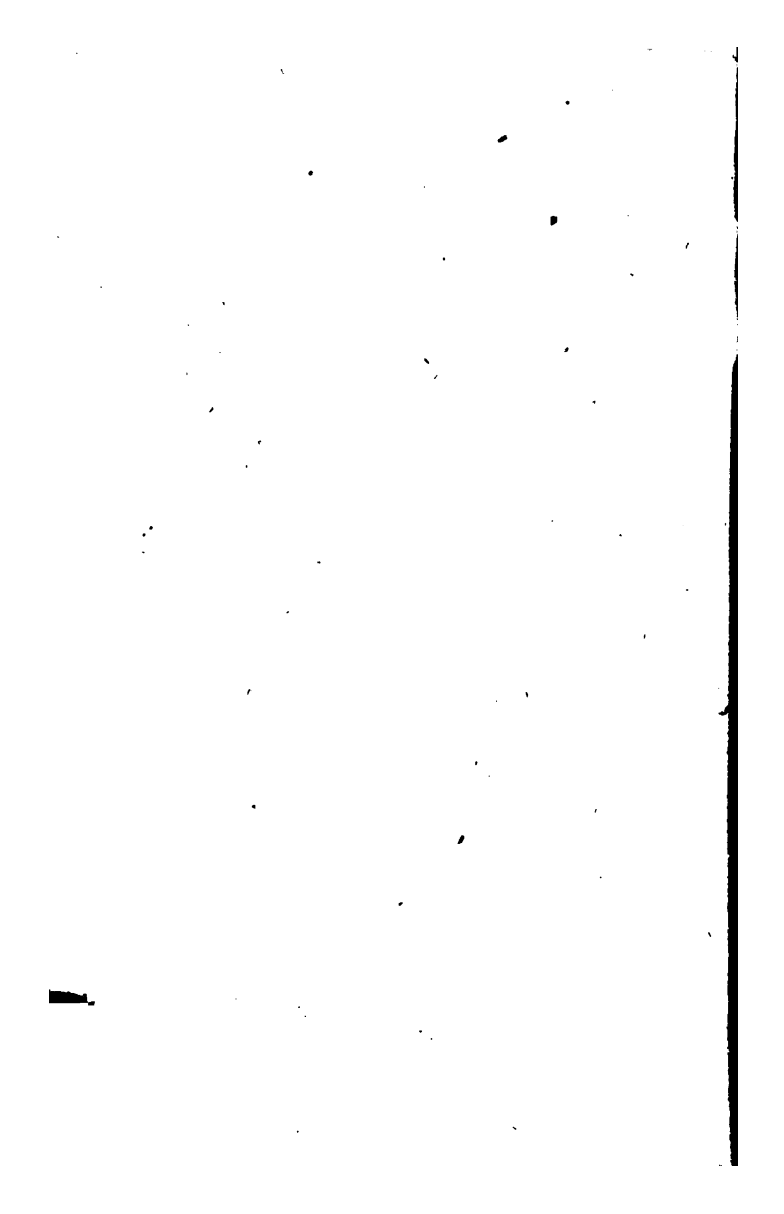


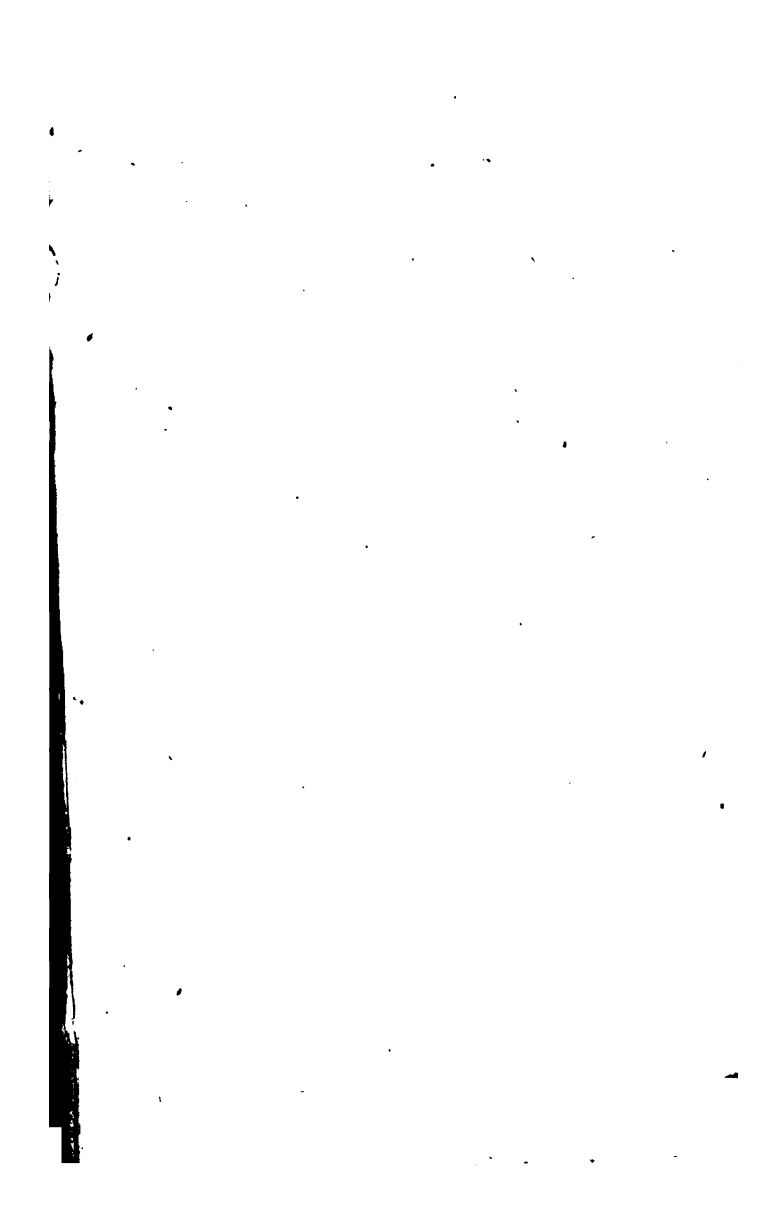




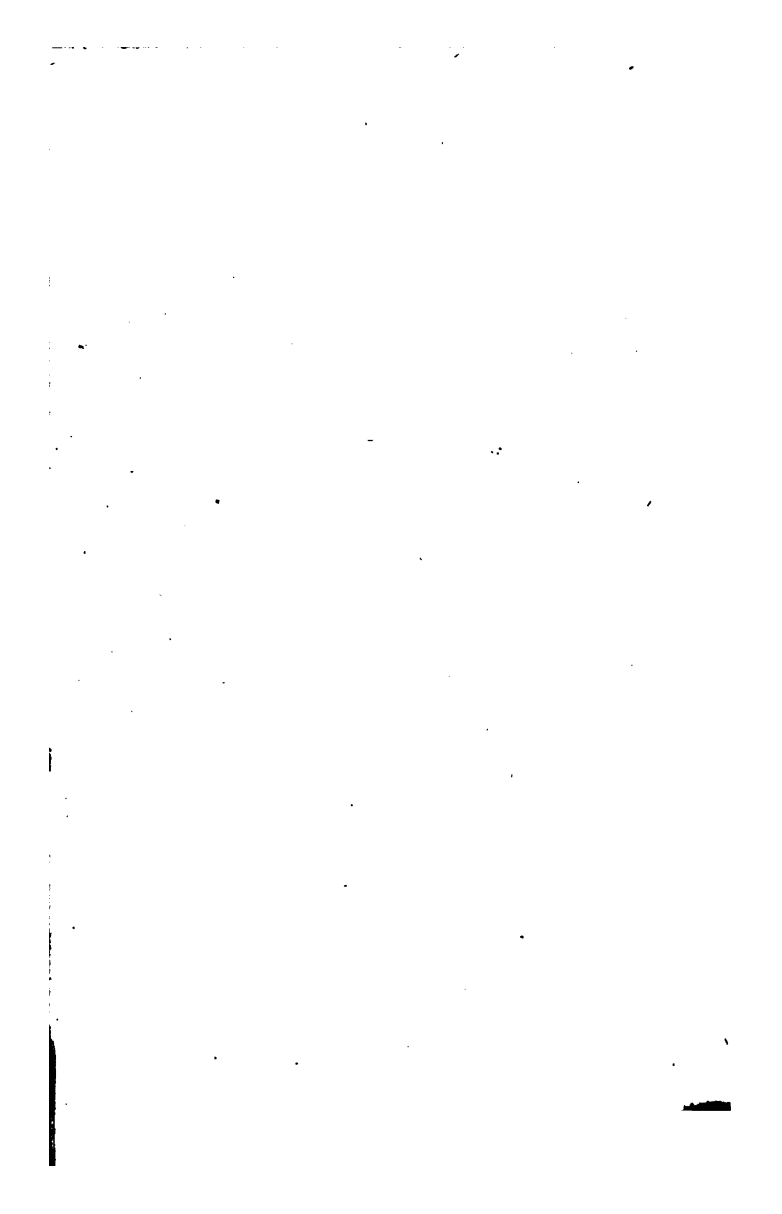














51
13

THE
FARMERS' INSTRUCTOR;

CONSISTING OF
ESSAYS, PRACTICAL DIRECTIONS, AND HINTS
FOR THE MANAGEMENT OF
THE FARM AND THE GARDEN.

ORIGINALLY PUBLISHED IN THE CULTIVATOR; SELECTED AND
REVISED FOR THE SCHOOL DISTRICT LIBRARY.

BY J. BUEL, ESQ.

"I know of no pursuit in which more real and important services
can be rendered to any country, than by improving its agriculture."
Washington.

IN TWO VOLUMES.

VOL. I.

NEW-YORK:
HARPER & BROTHERS, 83 CLIFF-STREET.

1847.

Entered, according to Act of Congress, in the year 1842, by
HARPER & BROTHERS,
in the Clerk's Office of the Southern District of New-York.

PUBLISHERS' ADVERTISEMENT.

Of all the interests in a civilized community, agriculture is, without doubt, the most important. In itself, it affords to the most numerous portion of every such community an eminently healthful and virtuous occupation, and a generous maintenance; while, with the surplus of its productions, it sustains all the other classes of society. It furnishes, moreover, to manufactures their most important materials; to commerce and trade their most numerous and valuable commodities; and, in short, to all the diversified branches of human industry, their principal encouragement and support. No country, therefore, can be in a condition truly prosperous without a flourishing agriculture.

To contribute towards the advancement of this all-important branch of our national industry, the following work has been prepared; and comprising, as it does, a great variety of communications, &c., from the most distinguished practical and scientific agriculturists of our own and other countries, the publishers cannot doubt but that it will prove

highly interesting and useful to the American farmer. The name of the Hon. J. Buel they deem a sufficient guarantee that the articles have been judiciously selected, both as it regards their intrinsic merit and their practical usefulness.

New-York, August, 1839.

CONTENTS
OF
THE FIRST VOLUME.

INTRODUCTION.

**On the Measures and Profits of Agriculture.—Application of
Science to Agriculture Page 13**

CHAPTER I.

**On the Classes of Soils, and their Properties, as determined by
external Characters 31**

CHAPTER II.

**On the Properties of Soils as determined by Chymical Anal-
ysis 44**

CHAPTER III.

**On the Properties of Soils as determined by their Vegetable
Productions 57**

CHAPTER IV.

On the Uses of Soils to Vegetables 65

CHAPTER V.

On the Means of increasing the Productive Power of Soils 70

CHAPTER VI.

On the Supply of Food to Plants by Manure and Culture . 76

CHAPTER VII.

On the Pulverization of Soils 79

CHAPTER VIII.

On Calcareous Manures	Page 83
---------------------------------	---------

CHAPTER IX.

On Lime and Gypsum	109
------------------------------	-----

CHAPTER X.

On Animal and Vegetable Manures	121
---	-----

CHAPTER XI.

The Atmosphere.—A Knowledge of its Elements and Offices important to the Farmer	135
--	-----

PRACTICAL HUSBANDRY.

INTRODUCTION.

Tillage	143
-------------------	-----

CHAPTER XII.

On the Rotation of Crops	145
------------------------------------	-----

CHAPTER XIII.

On the Comparative Advantages of Naked Fallows and Fal- low Crops	156
--	-----

CHAPTER XIV.

On the Culture of Wheat	164
-----------------------------------	-----

CHAPTER XV.

On the Culture of Indian Corn	171
---	-----

CHAPTER XVI.

On the Culture of Potatoes	189
--------------------------------------	-----

CHAPTER XVII.

On Grasses—Clover, Lucerne	196
--------------------------------------	-----

CHAPTER XVIII.

On the Culture of Roots	204
-----------------------------------	-----

CHAPTER XIX.

On the Culture of Madder and Hops	213
---	-----

CONTENTS.

xi

CHAPTER XX.

On Ploughing Page 220

CHAPTER XXI.

On the Harrow, Cultivator, and Roller 239

CHAPTER XXII.

On Draining 248

CHAPTER XXIII.

Account of Pattern Farm of Baron Von Voght . . . 268

A 2



THE
FARMER'S INSTRUCTOR.

INTRODUCTION.

PLEASURES AND PROFITS OF AGRICULTURE.

THE importance of agriculture to all the substantial interests of mankind is so fully recognised, that it may be deemed unnecessary to expatiate on the attention to which it is entitled, or to insist on the superior advantages which those nations must ever enjoy by whom it is the most skilfully practised. Some writers, indeed, without regarding the intimate connexion that subsists between every branch of human industry, have assigned to agriculture a superiority over every other art; but while claiming for it, to the fullest extent, pre-eminence over every mechanical trade, in all those considerations which mostly influence the choice of a profession, it would be inconsistent with that liberal spirit which forms so distinguished a feature in the character of the times, not to admit that it has no real title to precedence before the manufactures of the country; the object of both is to promote the general weal, and it is unjust to ascribe any peculiar degree of dignity to either. Custom, however, which often arbitrarily decides in opposition to reason, has decreed that individuals, even of elevated rank, may engage in the cultivation of the soil without descending from their station; a distinction which has not alone tended to raise it in the public estimation,

VOL. I.—B

but has also procured for it the more solid advantage of inducing many persons to embark in it, whose education and intelligence have suggested the idea, and whose fortune has furnished the means, of making experiments upon a scale which could only rarely have been attempted by the mere farmer; and which, although they have not been adopted to the extent that might be wished, have greatly contributed to the flourishing condition of the land and the consequent prosperity of the country. Nationally, therefore, it is rather matter of congratulation than of jealousy, that such a distinction has been made in favour of an art, in the successful prosecution of which the welfare of the community is so deeply involved; and, individually, it is indeed fortunate for many that, without any diminution of personal consequence, the independent may find an agreeable occupation, and the less opulent a source of additional income, in dedicating some portion of their leisure to the pursuits of agriculture.

Although other avocations may offer greater prizes in the lottery of life, yet, if we compare the advantages of rural industry with those of any other of the common occupations to which men devote themselves, we shall find that he who is engaged in agriculture has no reason to be dissatisfied with the lot which fortune has assigned him. Its superiority, in point of salubrity, over every sedentary employment, is too apparent to require illustration, and it affords more of those common enjoyments which constitute much of the elements of happiness, than any other state of equal mediocrity. The farm-yard, the orchard, and the dairy supply, almost without expense, abundant means of those gratifications usually termed "the comforts of life," besides many luxuries that are beyond the reach of people of humble fortune. Few persons, indeed, are insensible to the difference of mere animal existence, as enjoyed by the farmer who passes his

days in the healthful labours of the field, and that of the mechanic and the shopkeeper, who wear away their lives at the loom and the counter; but it is not in that alone that the advantage consists.

Of all the feelings which we cherish, none is dearer to us than consciousness of independence; and this, no man who earns his bread by the favour of the public can be said to enjoy in an equal degree with the farmer. Traders, as well as those termed professional men, are rivals, jealous of each other's success, and, let that be what it may, they still owe a deference to the world that is often galling to their spirit. But the farmer fears no competition. Individually, he has nothing to apprehend from the success of his neighbour; he solicits no preference, and he owes no thanks for the purchase of his wares. His business, though subject to more calamities than almost any other, is yet so divided among many risks, that he is rarely exposed to the hazard of total failure; the same weather which injures one crop often improves another, and the very difficulty of a critical season opens a field for exertion by which he is frequently a gainer.* Possessing on his land all the means of life, he is under no corroding anxiety regarding his daily subsistence; he is removed from those collisions of interest and those struggles for precedence which rouse the worst passions of our kind; and his constant observation of the beneficent dispensations of nature for the care of all her creatures, can hardly fail to impress him with a deep sense of that religion of the heart, which consists in the conviction of, and reliance upon, the care of an all-ruling and all-bountiful Providence.

Nothing tends more to enlarge the mind and to extend the sphere of our rational pleasures than

* "In twenty-four years' experience, upon a considerable scale, I always made the most money in difficult seasons."—*Pitt's Survey of Leicestershire*, p. 53.

the contemplation of the economy of nature ; and to those whom fortune has placed above considerations of pecuniary advantage, but who set a due value on intellectual enjoyment, the study of agriculture offers an inexhaustible fund of amusement as well as instruction. The same objects, seen under different aspects, present an infinite variety of feature ; and the most slender stock of appropriate knowledge, if aided by habits of observation and research, may be eminently useful in ascertaining facts hitherto unknown or unrecorded, and in thus illustrating a science which, however sedulously it has been explored, still opens a wide field for inquiry ; while, even if not fortunate in the attainment of any material benefit, the mere occupation of the mind in tracing the origin and progress of any novel improvement will be found productive of the purest gratification. It has been well observed by Sir Humphrey Davy, that the frequent failure of experiments, conducted after the most refined theoretic views, is far from proving the inutility of such trials ; one happy result, which can generally improve the method of cultivation, is worth the labour of a whole life ; and an unsuccessful experiment, well observed, must establish some truth or tend to remove some prejudice.

Through the progress of botanical science and the efforts made for the improvement of horticulture, many productions of the south have been naturalized in this country, and the introduction of the hothouse has made us familiar with the rarest exotics. Still, various foreign vegetables remain strangers to our culture, though adapted to our climate, and even some which are indigenous to our soil have not yet been brought into use, or are only slowly obtaining attention. It is not, indeed, to foreign nations alone that we are to look for new species of plants. Those which we already possess become so improved by cultivation, that new vari-

eties of the same race are constantly produced, until, at length, by continued melioration, the parent stock is either lost or neglected, and a new generation is created. Thus it has been supposed that not one of the numerous kinds and varieties of fruit, now found in our gardens and orchards, are what they were in their aboriginal state, and several appear to be absolutely new formations, the offspring of accident or skill rather than the spontaneous productions of nature. We are even ignorant of the native country, and existence in a wild state, of some of the most important of our plants; but we know that improved flowers and fruits are the necessary production of improved culture, and that the offspring, in a greater or less degree, inherits the character of its parent; the austere crab of our woods has been converted into the golden pippin, and the numerous varieties of the plum can boast no other parent than our native sloe. Thus, also, notwithstanding the attention bestowed by the ancients on the products of their gardens, and the probability that they were acquainted with a great proportion of the vegetables still in use, yet botanists find it difficult to reconcile the generic qualities of many plants, as they are described by the Greek and Roman authors, with the properties of those of the same species with which we are acquainted; we may, therefore, confidently infer, that an ample and unexplored field for future discovery lies before us, in which nature does not seem to have placed any limits to the success of our labours, if properly applied.

If the faculty of increasing the stores which nature has already provided for his support raises man above the brute, that of adding new productions to those in existence raises him above his fellow, and few subjects of contemplation can be more gratifying or more elevating to a reflective mind than this power, as it were, of creation, granted to his intel-

ligence and industry. Nor is it necessary to its enjoyment that we should be either botanists or natural philosophers; or that we should devote more than occasional leisure to the pursuit. So boundless, indeed, is the scope which it affords for experiment, that it is in the power of any one, possessed of the smallest garden and the least acquaintance with horticulture, so to improve the qualities of its products as to add something to the common stock of botanical riches, while enjoying a very delightful recreation. While the farmer, who will take the pains to mark the progress of his crops, and to select from them the most productive ears of corn, and the finest roots and grasses, for seed, may, by perseverance in such a plan, not only acquire wealth for himself, but confer an inestimable benefit on his country.

But it is not to the patriotism of the farmer that we appeal. That is a motive called into operation only on great occasions; it governs none of the common actions of life, and has no influence over ordinary minds; neither is it necessary to our purpose. Self-interest alone is a sufficient inducement to most men to exert themselves in their peculiar walk, and, if properly directed, it accomplishes the object of society as well as if they were swayed by higher principles of conduct. We, therefore, only mean to call attention to the fact, that, when pursued with skill and assiduity, husbandry offers one of the surest sources, not merely of independence, but of fortune: in proof of which assertion, numberless instances could be adduced of men now living in affluence, acquired solely by farming, as well as of others who have left large property to their heirs.

Among the latter, Bakewell stands foremost, not so much for the fortune which he realized, as for the important results of his experiments as a breeder, both to the public and to his numerous follow-

ers; inasmuch as the improvements which he effected in live-stock, or to which his example has led the way, have contributed largely to the increase of animal food, and opened a branch of farming as novel as it has proved lucrative. Efforts had, indeed, been made before his time to improve the different breeds; but they were comparatively feeble and ill-judged, until his penetration discovered the defects of the former system. He observed that the moderate-sized, compact, small-boned animals were generally in the best condition: he therefore endeavoured to improve these desirable points, and to remove what he deemed blemishes; until, by slow degrees, but with great judgment and perseverance, he produced those varieties of both cattle and sheep which have been distinctively termed, from his place of residence, the "*Dishley breeds*." Such was his success, that in one season he received twelve hundred guineas for the hire of three rams, and two thousand for the use of seven: and, during several successive years, he never obtained less than three thousand for his entire letting. Equally extraordinary prices have been given for cattle of superior quality; and it will be remembered that a Durham bull, *Comet*, belonging to Mr. Charles Colling, of Ketton, was actually sold, by public auction, for a thousand guineas.

Of Bakewell's immediate disciples, the Messrs. Culley, of Northumberland, were the most distinguished. They were among the foremost promoters of all agricultural experiments; and their superior intelligence, unremitting industry, and judicious application of the capital they gradually acquired, enabled them, from small original means, to leave their respective families each in the enjoyment of landed property to the amount of nearly four thousand pounds per annum, besides having largely contributed to the welfare of the surrounding country.

To these examples must be added that of one less known, perhaps, but not less worthy of imitation. The late Mr. Dawson, of Frogden, in Roxburghshire, was the son of a famer in moderate circumstances. He was born in 1734; and after having assisted his father during some years, and having also obtained an insight into the English mode of farming, in Yorkshire and Essex, he took the lands of Frogden, and there commenced the plan of growing alternate crops of grain and grasses, or roots, and particularly of turnips, which he cultivated according to Tull's method. He was also the first to introduce the Norfolk mode of ploughing, with two horses abreast, into that part of the country; and, by perseverance in the prosecution of these improvements, he lived, not only materially to advance the husbandry of the neighbouring district, but also to purchase a considerable estate, and to leave a numerous family in very great affluence. He is described by his biographer as having been "exceedingly regular in his habits, and most correct and systematic in all his agricultural operations. His plans were the result of an enlightened and sober calculation, and were persisted in, spite of every difficulty and discouragement, till they were reduced to practice. Every one who knows the obstacles that are thrown in the way of all innovations in agriculture, by the sneers and prejudice of obstinacy and ignorance, and, not unfrequently, by the evil offices of jealousy and malevolence, must be aware, that none but men of very strong minds and of unceasing activity are able to surmount them. but such a man was Mr. Dawson." Yet this, however praiseworthy, is only the character by which every man of business should be distinguished: it displays none of that high talent which is the gift of nature, and may deter, if not defy imitation; nor any of those great acquirements which are only to be attained by deep study and laborious research. Mr.

Dawson's success was the simple result of the discernment with which he had adopted the improvements of others, combined with the application of good sense, observation, and persevering assiduity, to an object which requires no extraordinary ability; and it is surely in the power of every man of plain understanding, and equal determination in the same pursuit, to follow in his footsteps, if not to attain equal eminence. He must, however, divest himself of prejudice, nor reject improvements merely because they are innovations on the practice of his grandfather. Not that a farmer should try every new experiment that is proposed, far less adopt any novel plan without due consideration. But if, after having weighed its advantages and disadvantages, with its applicability to the soil and means at his command, the former should appear to predominate, then let him afford it a fair trial; and let him recollect, that if a short cut to fortune sometimes lead a man astray, yet no one ever arrived at distinction by slavishly following the beaten track.

It is, indeed, deeply to be lamented, that such distinguished examples have not been more generally followed. Notwithstanding the acknowledged stride which agriculture has made in this country within the last half century, yet no science has been slower in its progress towards perfection; and, even admitting numberless existing instances of intelligence and spirited management among farmers of the higher class, it is still an undeniable fact, that the great mass of men are of a very opposite description. Brought up without sufficient education to enable them to comprehend the first principles of their art, acquiring it mechanically, as a mere trade, and either too dull or too indolent to seek information from books, they reject every proposed improvement as the visionary schemes of mere theorists, and even neglect them after their value has been proved by experience. Thus they inva-

riably pursue the same routine they have learned in their youth, and adhere, with the obstinacy of satisfied ignorance, to obsolete customs.

It is too true that this jealousy of written information has been in a great measure justified by many crude publications of inexperienced persons, and that the sneers of practical men at what they contemptuously call "*book farming*" are not wholly groundless. Much injury has been done to the cause of agriculture by sanguine speculations, which have only led to expense and disappointments; but all works on agriculture are not of that character; nor should it be forgotten that theory is the parent of practical knowledge, and that the very systems which farmers themselves adopt were originally founded upon those theories which they so much affect to despise. Neither can it be denied that systems grounded upon theory alone, unsupported by experiment, are properly viewed with distrust; for the most plausible reasoning upon the operations of nature, without accompanying proof deduced from facts, may lead to a wrong conclusion, and it is often difficult to separate that which is really useful from that which is merely visionary. The art of husbandry depends so much upon patient observation and the test of repeated trial, and is influenced by so many casualties beyond our control, that it would be rash to adopt any general rules as invariably applicable to the endless varieties of season, soil, and incidental circumstances. Prudence, therefore, dictates the necessity of caution; but ignorance is opposed to every change, from the mere want of judgment to discriminate between that which is purely speculative and that which rests upon a more solid foundation.

The prejudices of farmers against all innovation upon their established habits are as old as agriculture itself. In the dark ages of superstition, a man who, by any improved method, contrived to grow

larger crops than his fellows, was supposed to use supernatural means; and, if he escaped prosecution as a wizard, was at least shrewdly suspected of dealings with a power whom his more pious neighbours carefully avoided. New implements have been opposed much upon the same principle as the objection made about a century ago in Scotland, and so humorously as well as truly related by Sir Walter Scott, to the use of the winnowing machine;* and at this hour, the farmers in a large midland county assign as a reason for making the hinder wheels of their wagons preposterously larger than the fore, "that it places the body on a level in going up hill;" never reflecting that it will have to come down again, or to move upon even ground.

Even in the settled and customary management of a farm, unforeseen difficulties occur that baffle experience; and in some cases the merely practical farmer, who relies solely upon that, will be at a loss for expedients which an acquaintance with the practices of others might enable him to supply. There is, in this respect, assuredly much to learn, and no great difficulty in the task. For the rising generation, a more enlarged system of education is obviously the surest means; but the farmer who has not had that advantage, may easily acquire a practical knowledge of the various modes of culture and of rearing stock pursued in other districts, by occasionally visiting them after seedtime, and adopting

* "Your laddyship and the steward has been pleased to propose, that my son Cuddie suld work in the barn wi' a new-fangled machine for dighting the corn frae the chaff, thus impiously thwarting the will of Divine Providence, by raising wind for your laddyship's ain particular use by human sirt, instead of soliciting it by prayer, or waiting patiently for whatever dispensation of wind Providence was pleased to send upon the sheeling-hill."—*Tales of my Landlord, Old Mortality*, chap. vii. It was introduced in the year 1710, from Holland, by Fletcher of Saltoun, and its use was publicly denounced from the pulpit as impious.

Bakewell's advice, "*to see what others are doing.*" He will thus be enabled to compare, in the most effectual manner, their different fashions with his own; and it is in this manner that the intelligent farmers of the North—of Northumberland and of Norfolk—have surpassed their brethren in active enterprise and improved husbandry.

There is an old and often-repeated adage, that

"He who by the plough would thrive,
Himself must either hold or drive;"

and this, which has become a prevalent opinion, has deterred many a man who has sought relief from the cares of trade in the retirement of the country from availing himself of the profit, as well as the amusement, which he might have derived from farming. It is unquestionably true, that the man who, from early habit, is capable of holding the plough, must have great advantage in the practical knowledge of that most important operation over him who has not himself stood between the stilts; and it is earnestly to be recommended, that every youth who is destined to a farming life should personally assist in all the labours of the field, as the surest means of enabling him to direct them hereafter with effect; but nothing can be more erroneous than the supposition that the continuance of the toil is necessary to success. Formerly, indeed, when husbandry was confined to one dull round of drudgery, and when farms were generally so small that the profit depended as much upon the personal labour as the capacity of the tenant, it might be true; but, since the introduction of the present improved modes of cultivation, the more systematic attention to live-stock, and the enlarged size of farms; since, in fact, agriculture has become a science, rather than a mere mechanic art, the time of a man who occupies sufficient land to employ only a few labourers would be ill bestowed on manual toil. The axiom is not, indeed, always

applied in its literal sense; but then it is construed to mean that no man can hope to become a good farmer who has not been bred to the business. Undoubtedly personal experience is necessary; but it may be acquired at much less expense of time and money than is commonly imagined, by any man who will sedulously devote his powers of reflection to the principles, and his attention to the details of farming operations, with a firm resolution neither to relax in his exertions, nor to suffer himself to be daunted by disappointment in the commencement of his career. Such a man will be sure to succeed; and, as encouragement to perseverance, he may bear in mind that many of the most eminent agriculturists, and those who have introduced the most important improvements in rural economy, were not originally farmers.

Both the late Arthur Young and Marshall, whose writings have contributed so much to agricultural knowledge, were brought up to commerce; and it was not until the latter had attained to a mature period of life that he turned his attention to the plough. He then, with little other previous preparation than what he had acquired from reading, entered upon a farm, within ten miles of London, of three hundred acres of mixed soil, and which had been greatly mismanaged. This, for one so unpractised, was an arduous undertaking; yet within three months he discharged his bailiff and became his own manager. The consequence, as might be expected, was, that he at first committed some blunders; but, at the end of three years, he published his "*Minutes of Agriculture*," containing the memoranda of his operations from 1774 to 1777, which, although not free from error, yet show that he had even then attained to a greater proficiency than most of his contemporaries; but, to use his own language, "*attendance and attention will make any man a farmer.*"

VOL. I.—C

The notion that farming is unprofitable to any other than "regular-bred farmers," has been strengthened by numerous examples of persons who embarked in it during the late war, without any previous experience or any other incentive than an expectation, encouraged by the high prices of the day and the exaggerated representations of some agricultural writers, that it would prove an advantageous speculation. Impressed with that idea, they gave exorbitant rents for land; their stock was purchased at an equally extravagant rate; and, when the markets declined, they incurred enormous loss. The publication on the agricultural state of the kingdom in 1816, drawn up from the replies to a circular letter on the subject by the Board of Agriculture, teems with accounts of farms thrown up in every county; and, in many cases, the stock and crops were sold at less than half their original cost.

To these instances are to be added those, constantly recurring, of men in easy circumstances, who, without any knowledge of either the theory or practice of husbandry, engage in it merely for amusement, and, not condescending to stoop to the details, are exposed to numberless impositions of their tradesmen and servants. They pay higher wages and obtain lower prices than their neighbours; they grow large crops, but at an expense that the sale will not repay; and, retiring at length in disgust, they declare farming to be "a losing concern," but without acknowledging that it only became so through their own improvidence.

That such failures, however, do not always occur, we have the evidence of a very competent judge, who, alluding to persons who, having been in other lines of business, yet, having a strong inclination for rural occupation, had betaken themselves to farming as a profession, says, "this class forms the most intelligent and accurate of husbandmen. Like converts in religion, they have more zeal, give more

application, in short, have fewer prejudices to surmount, and more enthusiasm for their new profession, than those who have been brought up in it from their infancy. They are, however, at the first outset, more liable to error or mistake, from the want of practice; but their indefatigable attention makes more than amends for their ignorance of the minutiae of the art: and as they have been at some pains to acquire a knowledge in the theory of agriculture, and hence established their ideas on rational principles, they most commonly, in the end, make a distinguished appearance, as their labours, if judiciously performed, though often in a new and experimental channel, seldom fail of being crowned with success."

Thus, in every country, the condition of the people is seen to depend upon the degree of skilful labour which it can command: but the plough is the prime mover of all; for, until a sufficiency of food be produced for the common consumption, no one can be spared from the cultivation of the land; and it is obvious that in proportion to the perfection of that cultivation will be the amount of subsistence obtained, and the number of spare hands left for other purposes. The means of support in other branches of industry being thus secured, the demand for the produce of the land increases along with the produce of that labour; more hands are then required for its cultivation, and these again require more manufactures. Thus industry and wealth keep pace with agriculture, and, each stimulating the other, contribute to the national prosperity. That such is the effect of agriculture on the welfare of the community, is proved by the history of its progressive improvement, and of the consequent change in the mode of living.—*Introduction to British Husbandry.*

SCIENCE OF AGRICULTURE.

Application of Science to Agriculture.

"THE application of science to agriculture affords the materials of interesting and useful study. Chymistry ascertains the nature and constituents of soils, the mode of action of manures, and the substances fitted for the nutrition of plants; botany and vegetable physiology treat of the structure, the properties, and the use of plants; animal physiology and medical science relate to the form of animals, their properties and diseases; and mechanics are applied to the construction of machines and rural works."—*Low's Elements of Practical Agriculture.*

To the Editors of the Cultivator.

"I think, in the *Cultivator*, you ought to dwell continually on the importance of science to agriculture; I mean of all the applicable science the world has got: and the world is getting more every day, but with very little thanks to America. We want to see the application of geological and chymical science to the different processes in agriculture. If a knowledge and conviction of the essential importance of lime to the growth of wheat could be brought home to the farmers on the Mohawk river, it would be worth to them a million of dollars. In this section of the state (the west), God has spread lime over our fields, and mingled it with the soil; hence we are raising thirty and forty bushels of wheat per acre. On the Mohawk river, God has given to the farmers lime in abundance, *but has not spread it.* A knowledge of the process of burning and spreading lime over their fields would enhance the value of their farms fifty per cent."—*J. Wadsworth.*

REMARKS.—We commend the zeal which our cor-

respondent evinces for the diffusion of agricultural science, and agree with him as to its value in practical husbandry. We are promulgating its principles in the *Cultivator* as far as we think the public taste will warrant us. But we ask gentlemen of scientific knowledge to aid us in applying geological and chymical science to the labourers of the field.

We are not certain that lime is the *only* requisite in the valley of the Mohawk to restore the soil to its former fitness for the wheat crop; yet it may be, and the experiment deserves trial. The valley of the Mohawk and west Vermont were, within the recollection of the writer, the districts which furnished nearly all the wheat which was bought in Albany, Troy, and Lansingburgh. The former now sends to market but a trifling amount, and the latter does not grow enough, nor half enough, for its own consumption. We have little doubt but these districts may again become wheat-growing districts by the aid of agricultural science, and the value of their products greatly enhanced. But the present generation will neither acquire nor apply that science. This must, as in every other business, be learned in youth, and be incorporated with practical instruction. We must look to the rising generation for these improvements, and we must qualify our sons, by timely education, to make them. What that is useful in this business of life does the young farmer learn in school, if we even embrace schools of the higher order! The professional man learns in his school many of the fundamental maxims of science and rules of practice which are to govern him in his profession. Yet the agriculturist, whose business embraces a far greater scope of science than any one profession, and the profits of whose labours depend essentially upon the application of this science, learns nothing in his school which can forward him in the great business upon which not only his individual success depends, but which con-

stitutes the main source of the public prosperity. The studies of common schools, with competent teachers, might be rendered highly useful to agriculture, by imbuing the mind of the young farmer with the elementary principles of the business which is to occupy him through life.—*Ed. Cult.*

CHAPTER I.

The Classes of Soils, and their Properties, as determined by external characters.

THE soil is the upper portion of the ground in which plants are produced. It forms a stratum of from a few inches to a foot or more in depth. It is usually somewhat dark in colour, arising from the mixing with it of the decomposed stems, leaves, and other parts of plants which had grown upon it, and in part often by the presence of animal substances. It is this mixture of organic bodies, in a decomposed or decomposing state, with the mineral matter of the upper stratum, which distinguishes this stratum from the subjacent mass of earth or rock, to which the term subsoil is applied. The decomposable organic portion of the soil may be termed *mould*; and it is the presence of mould, accordingly, which distinguishes the soil from the subsoil.

Soils are very various in their fertility and texture. With relation to their power of producing useful plants, they may be termed rich or poor: with relation to their texture, they may be termed stiff, and free or light. The stiff soils are those which are tenacious and cohesive in their parts; the light or free soils are those which are of a looser texture, and whose parts are easily separated. But the cohesive soils pass into the loose by imperceptible gradations; and hence, though all soils may be termed rich or poor, stiff or light, they are so in every degree of fertility and texture.

All soils which possess this tenacious or cohesive property in a considerable degree, are termed *clays* or clayey soils; while all the looser soils are termed *light* or *free*. And all soils are more or less

clayey, or more or less light, as they possess more or less of this tenacious or cohesive property, or of this looser texture.

The fertility of soils is, *ceteris paribus*, indicated by the greater or smaller proportion of mould which enters into their composition. When soils are thus naturally fertile, or are rendered permanently so by art, they are frequently termed *loams*. Thus there are clayey loams and light loams; and peat itself may, by the application of labour and art, be converted into loam.

The parts of plants which grow upon the surface, and are mixed with the mineral matter of the soil, may decompose and become mould. Under certain circumstances, however, the plants which have grown upon the surface do not decompose, but undergo a peculiar change, which fits them to resist decomposition. They are converted into what is termed peat, and the soils formed of this substance are termed *peaty*. The peaty soils are the lighter class, and are distinguished from all others by peculiar characters.

Soils, then, may be distinguished from each other,

1st, According to their texture; in which case they may be divided into two classes: 1st, by the stiff, denominated clays; 2d, the light or free, comprehending the peaty.

2d, According to their fertility, or power of producing useful plants; in which case they are termed rich or poor.

Soils, too, from particular causes, may be habitually wet or habitually dry. Soils, therefore, may be further distinguished by their general relation to moisture. When water, from any cause, is habitually abundant, the soils may be termed wet; when not habitually abundant, they may be termed dry.

Subsoils, it has been said, are distinguished from soils properly so termed by the absence of mould,

Plants, in growing, may extend their roots into the subsoil, and, decomposing there, mix with it. But this is in small quantity; and, for the most part, the subsoil is readily distinguishable by the eye from the upper stratum or soil, by the absence of organic matter in a decomposed or decomposing state.

Subsoils may either consist of loose earthy matter, like the soil, or they may consist of rock. Subsoils, therefore, may be divided into two classes, the rocky and the earthy.

When soil rests directly upon and extends to the rock, without any intervening bed of looser earthy matter, the soil will frequently be found to be similar, in the composition of its mineral parts, to the rock upon which it rests, it having been formed by the gradual disintegration of that rock. This is chiefly found to be the case with the soils of mountains; for, in plains, the soil is generally formed, not by the disintegration and decomposition of the rock upon which it rests, but by the intermixing together of the disintegrated parts of different rocks and mineral strata.

The rocky subsoils consist of granite, sandstone, limestone, chalk, and other mountain rocks of a country. They are sometimes easily penetrated by the water that falls upon the soil, and are then termed free or porous; and sometimes they resist the percolation of water, when they are termed close or retentive.

The earthy subsoil may, in like manner, be divided into the close or retentive, and the free or porous. The retentive are those which, from containing clay, are tenacious and cohesive in their parts, and little pervious to fluids: the porous are those which, from having less of clay in their composition, are more readily permeable.

Whether the subsoil be retentive or porous, the soil which rests upon it should be of good depth. If the soil be shallow on a retentive subsoil, it is

affected too greatly by the alternations of dryness and moisture. And if, again, a shallow soil rest upon a porous subsoil, the moisture of the soil is too easily acted upon and exhausted by heat.

A subsoil, in so far as mere texture is concerned, should be neither too retentive nor too porous. But although this intermediate condition is, in most cases, the best, yet, in a very cold and moist country, a free or porous subsoil is, for the most part, to be preferred to one which is close and retentive. The soil, besides being affected by the texture of the subsoil, is sometimes also affected by the nature of the mineral substances of which the subsoil is formed.

If the subsoil be rocky, it is desirable that it be calcareous rather than silicious; chalk or limestone, for example, rather than quartz. Sometimes the subsoil contains matter which is directly injurious to the growth of plants. This matter is generally found to be the oxydes of metals in combination with acids. Subsoils of this kind are usually distinguished by deepness of colour.

Soils, then, it is seen, are affected in their properties not only by their own texture and composition, but by the texture and composition of the subsoil; and they are divided into the stiff or clayey, and the light or free.

The clayey soils have, as their distinguishing character, the adhesiveness of their parts; and this property alone will enable even the inexperienced to discriminate them. A stiff clay, when dried either by natural or artificial heat, becomes so hard as to resist a considerable mechanical pressure. On account of the tenacity of such soils, they are tilled with more difficulty than the freer soils. They require, to fertilize them, a larger proportion of manures; but they retain the effects of these manures for a longer time. They are better suited to the cultivation of plants with fibrous, than with

tuberous or bulbous roots. Soils of this class, as of every other, possess many degrees of natural fertility. The poor clays form, for the most part, a very unprofitable soil, because, while their powers of production are inconsiderable, the expenses of tilling them are large. The clay soils of this character are generally of little depth, and rest upon a retentive subsoil. The natural herbage they produce is coarse and little nutritious, and they are not well suited to the production of the cultivated grasses and other herbage plants. They are little fitted for the growth of turnips or other plants with bulbous and tuberous roots. Such soils have everywhere local names which sufficiently denote their qualities. They are termed, by a not improper figure, *cold soils*; and sometimes they are classed under the general name *moor*, which term is often used to denote soils, whatever be their nature, of a low degree of fertility.

Very different in their value and nature are the richer clays. These bear weighty crops of all the cultivated kinds of corn:* they do not excel the better soils of other classes so greatly in the production of oats, and still less in that of barley, in which lighter soils loams may surpass them; but they are unequalled for the production of wheat, and in many places derive their descriptive appellation from that circumstance, being termed *wheat soils*. They are well suited for the growth of the bean,† a plant with a weighty stem, and requiring a stiff soil to support it. They will yield large returns of the cultivated grasses and leguminous herbage plants,‡ though they are not so quickly covered with the natural herbage plants of the soil, when laid down to perennial pasturage, as the lighter soils.

* This term applies, in Europe, to wheat, barley, and the other small grains, and not to Indian corn, as in the United States.

† The bean here alluded to is the horsebean, little cultivated here, and not the kidney-bean which we grow.

‡ As pease, beans, &c.

Clays, like other soils, approach to their most perfect condition as they advance to that state which has been termed loam. The effect of judicious tillage, and of the application of manures, is to improve the texture of such soils as well as to enrich them. Thus, clays in the neighbourhood of cities become dark in their colour, and less cohesive in their texture, from the mixture of animal and vegetable matter, and thence acquire the properties of the most valued soils of their class.

Natural changes, however, yet more than art, have furnished the rich soils of clay. The best, for the most part, of the soils of clay, are those which are formed from the depositions of rivers or the sea. The finest natural soils of this and other countries are those which are thus formed. The deposition of rivers, indeed, are not always of a clayey nature. In mountainous districts, they generally form soils of the lighter kinds. Where the sea, however, is the agent, or where both the rivers and the tides combine their action, the depositions generally partake of the nature of clay. Such alluvial soils have everywhere local terms to mark their character and fertility. On the great rivers and estuaries in England, and what are termed *carses* in Scotland, fine and extensive districts of this kind exist. The next class of soils is the light or free. These are readily distinguished from the last by their smaller degree of tenacity. They are less suited for the production of wheat and beans than the clays, but they are better suited for the production of plants cultivated for their bulbs and tubers, as the turnip and the potato.

This class of soils may be divided into two classes or sub-classes, differing from each other in certain characters, but agreeing in the common property of being less tenacious in their parts than the clays.

The first of these sub-classes of the lighter soils has been termed the sandy.

The sandy soils are of all the degrees from barrenness to fertility. When wholly without cohesion in their parts, they are altogether barren, and are only rendered productive by the admixture of other substances. The cultivated sands part readily with their moisture on the application of heat. They do not become hard like the clays, and, making no considerable resistance to external pressure, they are tilled with little labour.

The poorer sands are almost always marked by the scantiness of their natural herbage. This character they possess in common with the poorer gravels. Other soils, even the poorest, may be thickly covered with the plants peculiar to them; but the poorer sands and gravels put forth their natural herbs with a sparingness which denotes the absence of vegetable nourishment.

But sand, without losing its distinctive characters as a soil, may possess a greater cohesiveness in its particles, and be fertile by nature, or rendered so by art, and then the soils denominated sandy become of deserved estimation. Rich sands are early in maturing the cultivated plants, and thence they are familiarly termed *kindly* soils. They are fit for the production of every kind of herbage and grain. They yield to the richer clays in the power of producing wheat, but they surpass them in the production of rye and barley. They are well suited to the growth of the cultivated grasses; and, when left in perennial pasture, they are quickly covered with the natural plants of the soil. But their distinguishing character is their peculiar adaptation to the raising of the plants cultivated for the bulbs and tubers of their roots.*

The next division of the lighter soils, and allied in the character to the sandy, is the gravelly.

Sands will frequently be found to be the produc-

* And to the culture of Indian corn.

tion of flat countries, gravels of the mountainous and rocky. The characteristic of the gravelly soils is the quantity of loose stones which they contain. These stones will be found to consist of those varieties of rock which the mountains of the country afford; and the nature of these rocks will frequently indicate the character of the soil; thus soils, of which the stony matter is very silicious, are generally found to be barren, while those of which it is calcareous are found to be fertile.

Sands, upon examination, will be found to consist of small particles of stony matter, and thus sands may be said to differ only from gravels in the more minute division of their parts. Yet, in this minuteness of division, there is generally sufficient to distinguish the two kinds of soils. The stony matter of the sand forms its principal component part, while the larger stones in the gravel, which give to it its name and its character, seem only to be mixed with the other necessary parts of the soil. The stone of the one has undergone a considerable mechanical division, while much of that of the other has only been loosened, in sensible masses, from its native bed. Any light soil, mixed with a sufficient portion of stones, is gravel: and gravel, therefore, is nothing else than the different kinds of light soils, mixed with a greater or less proportion of stones.

Gravels, like sands, have all the gradations of quality, from fertility to barrenness. The loose soils of this nature, in which the undecomposed material is great, and the intervening soil silicious, are held to be the worst of their kind. These are, in some places, termed *hungry* gravels, not only to denote their poverty, but their tendency to devour, as it were, manure, without any corresponding nourishment to themselves. As the texture and quality of the intervening earth improve, so does the quality of the entire soil; and gravels, like sands,

and clays, advancing through all the intermediate degrees, may become, at last, of great fertility. The rich gravels will produce all the cultivated kinds of grain. Their looser texture renders them less suited than clays to the growth of wheat and beans; but they are admirably adapted to the growth of barley and oats. They are quick in their powers of producing vegetation; and from this quality they are, in some places, termed *sharp* or quick soils. They readily admit of alternations of herbage and tillage, and improve in a state of perennial pasturage. They are generally trusty soils with regard to the quality of the grain which they yield; and in this respect they differ from many of the sands, in which the quality of the grain produced does not always accord with its early promise. It is well, then, even in the best sands, to see a tendency to gravel, which denotes a sharpness, as it is termed, in the soil. Gravels, like sands, are suited to the culture of the different kinds of plants raised for the bulbs and tubers of their roots; and they are in so peculiar a degree suited to the growth of turnips, that in some parts they receive the distinguishing appellation of *turnip* soils.

The last division of the lighter soils consists of those which are termed peaty.

The matter of the soils of this class is dark in its colour, spongy in its texture, and full of the stems and other parts of plants, either entire or in a state of partial decay. It is generally tough and elastic; and, when dry, loses greatly of its weight, and becomes inflammable. These, the most observable characteristics of the soils termed peaty, will distinguish them, in their natural state, from every other; and even when they shall have been greatly improved by culture, enough of their original characters will remain to make them known.

Peat, it has been said, consists of vegetable matter which has undergone a peculiar change. Under a de-

gree of temperature not sufficiently great to decompose the plants that have sprung upon the surface, these plants accumulate; and, aided by a certain degree of humidity, are converted into peat, which is either found in strata upon the surface of plains, or accumulated in great beds upon the tops and acclivities of mountains, or in valleys, hollows, and ravines. Successive layers of plants being added to the mass, it continues to increase, under circumstances favourable to its production. Water is a necessary agent in its formation, and we may believe, too, a peculiar temperature, since it is only in the cold and temperate, and not in the warmer regions of the earth, that it is found to be produced. The plants which form it have not entirely decayed, but still retain their fibrous texture: and from the action of certain natural agents, have acquired properties altogether distinct from those which, in their former condition, they were possessed of. They have now formed a spongy, elastic, inflammable body, and so different from the common matter of vegetables as to be highly antiseptic.

The plants whose progress towards decomposition has been thus arrested, are very various. Over the greater part of the surface of the primary and transition districts of colder countries, the peat is chiefly formed of mosses and other cryptogamic plants, mixed with the heaths and other plants which had grown along with it. Sometimes the peat has been formed in swamps and lakes, and at other times the humidity of the climate has been sufficient to form it in one continued bed, covering the whole surface of the country.

Of the heaths which enter into the composition of peat, that hardy species, the common ling, *Calluna vulgaris*, is the native inhabitant of the alpine countries of northern Europe, and grows in vigour, and overspreads the surface where hardly any other of the larger plants could live. But although this

and other species of heath are very generally converted into peat, this is not necessarily or universally so. By the growth and decay of the roots and stems, a soil is indeed formed; but then this may take place in the same manner as in other soils, and without the actual conversion of the upper stratum into peat. This, however, in the case of the cold and moist countries of the north of Europe, is comparatively rare, for generally the plants, from the slowness of decomposition of their ligneous roots and stems, are wholly or partially converted into peat. In the cases in which these plants are not converted into peat, a dry and turfy soil is formed, very different in aspect from that formed by the gramineous and other easily decomposed plants, but still produced in the same manner, though, like the peaty soils, elastic and inflammable, on account of the greater quantity of ligneous matter in its composition. The soil itself is generally thin, and little favourable to vegetation. It usually rests upon a subsoil of silicious sand, and sometimes of chalk, and then it is comprehended under the class of soils termed light.

The soil formed of peat would, from its vegetable composition, seem to contain within it the necessary elements of fertility, and yet this is not found to be so. The excess of vegetable matter which it contains is injurious rather than useful. In the state of nature, it is often found to be as barren as the sand of the desert, and scarcely to deserve the name of soil until the labour of art has been extended to its improvement; and even then it is not entirely divested of its original characters.

The effect of thorough draining off the water of peat, continued for a long time, is to carry away the antiseptic matter which it contains. When the water of peat ceases to be turbid and comes off clear, then we have the assurance that the peat is freed of the principles injurious to vegetation. This

is the greatest improvement of which peat is susceptible ; and when we have brought it to this condition, the main difficulty of improving it has ceased.*

Peat may, then, be brought to the state of what has been termed loam. In this ameliorated condition it becomes a soil of the lighter kind, well suited to the culture of the larger-rooted plants. It is dark in its colour, like the richest vegetable loam, and, to the experienced eye, may pass as such. But still, unless greatly corrected in its texture by the application of the earths, it is found to be porous and loose, too quickly saturated with moisture, and too easily freed from it. In this improved condition it will yield bulky crops of oats and barley, although the quantity of the grain will not always correspond with the weight of the stem, nor the quality of the grain with its quantity.

Soils, then, we have seen, may be distinguished according to their texture and constitution, when they may be divided into two classes: the stiff or strong, denominated clays; the light or free, subdivided into the sandy, gravelly, and peaty; and all these, again, may be distinguished,

1st, According to their powers of production, when they are termed rich or poor; and,

2d, According to their habitual relation with respect to moisture, when they are termed wet or dry.

This simple nomenclature of soils is sufficiently intelligible to the practical farmer. The farmer chiefly regards soils with relation to their fertility, and the means of cultivating them; and he natu-

* These characteristics of peat do not *generally* apply to the matters found in our swamps and marshes. We have no heaths, and the vegetable matter is more broken down by the heats of our summers than it is in the north of Europe. Draining, in most cases, converts our swamps into productive soils.

rally classifies them according to these views. A main distinction between soils, in practice, is founded upon their comparative productiveness; and this is the distinction which is most important with regard to mere value. We constantly refer to soils with reference to their good or bad qualities, without adverting to the particular circumstances which render them of good or bad quality. We speak familiarly, for example, of land worth 40s., 50s., and 60s. the acre, without considering whether it be a fertile clay, a fertile sand, or a highly-improved peat. We speak of it with reference to its fertility and value alone. But those other distinctions, which are derived from its constitution and texture, are essential when we regard the manner of cultivating such a soil; for the same method of tillage, and the same succession of crops, as will be afterward seen, do not apply to all rich or to all poor soils, but are determined by the character of the soil, as derived from its other properties.

Though soils are thus distinguished by external characters, they pass into each other by such gradations that it is often difficult to say to what class they belong. These intermediate soils, too, are the most numerous class in all countries. The soils termed peaty, indeed, form a peculiar class, always marked by distinctive characters; but even these, when mixed with other substances, pass into the earthy soils by imperceptible gradations. We may say, therefore, that the great part of soil consists of an intermediate class, and that it is often difficult to bring them under any division derived from their texture alone. Such soils, however, can always be distinguished by their powers of production. They are good, bad, or intermediate between good and bad; and their relative value is determined by the produce which, under similar circumstances, they will yield.—*Low's Elements of Practical Agriculture.*

CHAPTER II.

The Properties of Soils, as determined by Chymical Analysis.

HAVING examined the external characters of soils, we might now inquire into their properties, as determined by chymical analysis. This, however, is a branch of the extensive subject of agricultural chymistry into which it would not be consistent with the practical and elementary nature of this work to enter at length. It is merely proposed, therefore, to direct the attention of the student to this part of the science of agriculture, and to make known to him a few results which have been arrived at.

The soil has been said to be a compound of mineral substances, mixed with a portion of vegetable and animal matter.

The vegetable and animal matter of the soil, to which the term mould has been applied, exists either in a state of mixture, or of chymical union with the minerals of the soil.

The mineral matter of the soil forms greatly the larger part of it, and necessarily consists of the same substances which constitute the mountain rocks and mineral masses which are found on the earth, and which form its crust or covering. The hardest rocks break down by degrees, and are decomposed by the influence of air and moisture. Sometimes the decomposed matter remains upon the rocky basis from which it had been derived, and there forms a soil; but more frequently the action of water has mingled together the different mineral

masses and strata which are found over all the earth.

The great body of the soil, then, is a mixture of the various mineral substances which are upon the earth, and is resolvable into the same constituent parts. Now all the rocks and other mineral masses which exist on the surface of the earth are found to consist of a few bodies, the principal of which are four earths : silica, alumina, lime, and magnesia ; and the oxyde of iron, soda, and potassa. In like manner, the great mass of the mineral part of the soil is resolvable into silica, alumina, lime, magnesia, the oxyde of iron, soda, and potassa.

The manner in which this compound body may be conceived to exist, is the following: Let it be supposed that the different minerals on the surface of the earth are more or less decomposed, broken, ground down, as it were, and mingled together.

Some are in the form of stones, and are therefore merely species of the different rocks of a country. These form loose stones and gravel, which we see accordingly to be everywhere mingled with the soil, and to form often a great proportion of it.

A more minute comminution reduces these mineral substances to sand. This is the form in which the largest part of all soils exists; and when it is in a very considerable proportion to the whole, the soil is termed sandy.

When the parts are more comminuted still, and reduced by chymical or mechanical means to powder, the soil appears to be in the state most favourable to vegetation. All our finest soils contain a large comparative proportion of their parts reduced to this state of division; and where none of this finely-divided substance, or a small quantity of it only exists, the soil is barren.

Of the substances which form the constituent

parts of minerals, the most widely diffused is silica. This earth forms the principal constituent part of all the fossils and mountain rocks of which the crust of the earth is composed. Those in which it exists in large quantity are usually very hard. The sand of the seashore is mostly silicious, and silicious sand forms vast deserts in every part of the world.

In quartz and in feldspar this earth exists nearly pure, and it forms 98 parts in 100 of common flint. It is from its abundance in quartz, a mountain rock of universal diffusion, and in feldspar, which is likewise one of the most abundant minerals in nature, that silica is important as forming a principal constituent part of all the loose mineral matter of the surface of the earth, and, consequently, of all soils.

Quartz is a rock of constant occurrence, and its disintegrated parts have been everywhere washed into the plains, to form an element of the soil. Quartz has been found to consist of silica, alumina, and a small quantity of oxyde of iron. Quartz is also an ingredient part of sandstone, and other rocks of general diffusion. It enters largely into the composition of granite and other primary rocks. It forms, in short, a part of the rocks in all the series of formations which geologists enumerate; and thus silica is the most universally-diffused mineral substance on the surface of the earth, and forms a part, accordingly, of every soil that is known to us.

Alumina, next to silica, is the most generally diffused of the earths. United with silica, it forms a great proportion of all the rocks and mineral-masses on the earth. It is, accordingly, everywhere found, and forms a part of every soil not wholly barren. Kneaded with water, it becomes a ductile paste, and is the substance which chiefly gives their plastic and ductile characters to the soils termed clays.

Silica and alumina, then, forming the largest part of the rocks and minerals which exist upon the sur-

face of the earth, enter the most largely into the composition of soils; and in these they are found to exist, either as grains of sand, or as gravel, or in the form of an impalpable powder.

Lime, the next of the earths, is one which is of wide extension, and performs an important function in the vegetable economy.

In nature, this mineral is usually found in combination with acids. Combined with carbonic acid, it constitutes the numerous varieties of marble, limestone, and chalk. In this and other combinations, it exists in rocks, in soils, in the waters of the ocean, in plants, and in animals. It forms great rocks and mineral strata, and numerous fossils in combination with silica and alumina.

It is chiefly from the carbonate that the lime used in agriculture is derived. By exposing the carbonate to strong heat, the carbonic acid is driven off, and that which remains is the caustic earth, to which we give the name of quicklime. This substance has a strong affinity for water, which it will absorb from the atmosphere. When the water is applied in quantity, it is absorbed by the lime, with a great evolution of heat; and this is the process of slacking so well known. The lime, thus combined with water, attracts carbonic acid, and again becomes carbonate of lime; although, in this state of carbonate, it presents external characters entirely different from those which it possessed in its original state of marble, limestone, and chalk. But it is in external characters only, and in the lesser degree of cohesion of its parts, that it differs, for otherwise the substances are the same.

By the minute division of its parts by heat, we are enabled to apply lime to the soil in the shape of a finely-divided powder, and thus in the best form for improving the texture of the soil. It is from this cause, doubtless, as well as those important purposes which it serves as a manure, that this

earth is of such importance to the husbandman. Could we apply the earths silica and alumina to the soil in their pure state, or could we reduce them by mechanical or chymical means to powder, we should be able to apply them in a form calculated to improve the texture of the soil.

Lime exists in all soils formed by the decomposition of rocks; but in soils formed wholly by the aggregation of vegetables, as peat, it does not necessarily exist. It improves the quality of all soils, whether they are formed of silica, alumina, or vegetable matter.

Silica, and alumina, and lime, forming the principal part of soils, and, where any one of them prevails, giving its character to the soil, it is frequently convenient to distinguish soils, as being silicious, aluminous, or calcareous. Where silica prevails, as in the case of many sands, we may call the soil silicious; where clay prevails, we may call the soil aluminous; and where lime exists in quantity, as in the case of chalk, we may call the soil calcareous. Thus, in addition to the less artificial division of the farmer, derived from the texture and external characters of the soil, we may use those derived from its composition.

Magnesia, in various states of combination, exists in nature in considerable quantity. It is generally found in combination with acids, as the carbonic. In mountain rocks and fossils, it exists along with silica, alumina, lime, iron, and other substances. The minerals of which it forms a part generally feel soft and unctuous. It is the principal constituent of various mountain rocks, as serpentine and chlorite-slate; and thus, being an element in many rocks and fossils, it must form a considerable part of soils. Magnesia, however, is less generally diffused than lime, and may, perhaps, perform a less important function in the economy of vegetation.

When it exists in such quantity as to give a character to the soil, we may term the soil magnesian.

The next substance that exists largely diffused in the mineral kingdom, is oxyde of iron.

Iron, as it is the most useful of the metals, so it is generally diffused on the earth. It is derived, for the purposes of the arts, from a series of minerals termed ores of iron. It is found extensively in mountain rocks and many fossils; and it exists, accordingly, in more or less quantity, in almost every soil. Its precise effects, however, on the productive powers of soils, have not been well determined, some soils where it exists being extremely barren, while in some very fertile soils it exists in large quantity. Soils which contain much of iron may be termed ferruginous.

The alkalies, soda, and potassa, are also found in soils, being extensive products of the mineral kingdom. They are found in nature, or combined with various acids. Muriate of soda, or common salt, one of these combinations, is a widely-diffused mineral in soils, a certain quantity of which is probably necessary to the existence of plants, while in excess it is known to be injurious.

Soils, then, consist chiefly of silica, alumina, lime, magnesia, oxyde of iron, potassa, and soda, together with a portion of organic matter.

From various experiments, it is known that plants consume, in growing, the decomposing animal and vegetable matter which the soil contains. It is rendered probable, also, by experiments, that a portion of the earthy matter of the soil—the silica, the alumina, the lime, as well as various saline substances contained in it—is absorbed by the plant, though in minute quantity as compared to the animal and vegetable matter absorbed.

Farther, the medium of supply of the matter of nutrition contained in the soil may be regarded as
VOL. I.—E

water holding in solution the vegetable, animal, and other matters which pass into the roots of plants. The soil, then, may be chiefly regarded,

1st, As the instrument for fixing the roots of plants in the ground; and,

2d, As a medium for conveying to them the water holding dissolved the different substances which pass into the plant.

The air may be considered as a vehicle for conveying water to the soil. It is continually charged with aqueous vapour, which partly descends to the earth in rains, and is partly deposited in dews in the cool of the night. In many countries it never rains at certain seasons, and the whole moisture is supplied by the dew. In this case in an especial degree, and in all cases in a certain degree, the power of the earth to absorb moisture from the air may be regarded as connected with the means of the soil to nourish plants.

All our fertile soils, accordingly, have a power of thus supplying themselves with moisture, and of retaining it for the proper time; while infertile soils either have less of this absorbent power, or retain the fluid absorbed for a shorter time.

Of the different matters which enter into the composition of soils, animal and vegetable substances possess the greatest power of absorbing moisture; and the addition of animal and vegetable substances always increases the fertility of soils.

Of the pure earths, the least absorbent is silica, and it is that also which parts the most readily with its moisture. A soil consisting of too great a proportion of silicious sand is always infertile. It imbibes the aqueous vapour of the atmosphere with slowness, and parts with it quickly. A soil of silicious sand will scarcely be penetrated by the dew of night, and will part with it on the first action of the morning rays of the sun.

While pure silica will imbibe scarce a fourth part

of its weight of water, lime will absorb nearly its own weight, and alumina two and a half times its weight. But while the silica will absorb a smaller quantity than alumina or carbonate of lime, it will allow it to evaporate two times more quickly than carbonate of lime equally divided, and five times more quickly than alumina in the same state.* The addition of carbonate of lime or alumina to a soil containing too much silica, never fails to increase its powers of absorption and its fertility.

The order in which the principal substances that enter into the composition of soils possess an absorbent power, is the following :

1. Animal and vegetable substances.
2. Alumina.
3. Carbonate of lime.
4. Silica.†

It appears, too, that the more perfectly the parts of the soil are comminuted, decomposed, and reduced, the greater is the power of absorption which they possess ; and that the larger the proportion of the soil is which exists in this minutely divided state, the greater, *ceteris paribus*, is its fertility.

But, although certain earths in their separate state have thus a greater power of absorption than others, it does not follow that a soil consisting chiefly of that one earth would possess a greater power of absorption than a soil composed of a mixture of earths, even though these earths should in themselves be less absorbent. Thus, a soil consisting chiefly of aluminous earth, though alumina be itself the most absorbent of all earths, taking water up in the greatest quantity when poured upon it, as well as retaining it the longest, would not really be so absorbent as if it were more mixed with other earths. Hence the stiffer clays are not the soils which absorb water readily from the atmosphere ;

* Chymistry applied to agriculture, by Chaptal. † Chaptal.

for, when the weather is dry, such soils become indurated upon the surface, which presents an obstacle to absorption; and thus we find that in hot weather the vegetation of very stiff clays is almost as soon injured by drought as that of light soils, and much more quickly than that of good loams.

A mixture of silicious sand, then, with a very aluminous soil, although the sand be the less absorbent substance of the two, seems to increase the general power of absorption from the atmosphere; so also does a mixture of lime, and, in an eminent degree, of animal and vegetable matter.

It is not, therefore, the prevalence of any one earth that constitutes a soil well fitted to absorb humidity. A mixture of certain proportions of alumina and silica, of carbonate of lime and vegetable and animal matter, appears to be the best suited for absorbing the humidity of the atmosphere, of preserving it, and transmitting it the most regularly to the plant.

Neither does it appear that the prevalence of any one earth in a soil is favourable to vegetation. Too great a proportion of alumina forms a soil too stiff and tenacious. Such a soil will, from this cause, be found to be unproductive. A soil consisting of carbonate of lime only, as we see in the case of chalk, is a bad soil. A soil consisting of alumina and carbonate of lime only, as we see in the case of clay-marl, is unproductive as a soil, until mixed with other substances.

A soil consisting chiefly of silica is often so barren as to be incapable of sustaining vegetation at all.

Some, founding on the experiments of Sir Humphrey Davy, have been led to the opinion that the fertility of soils is directly indicated by their power of absorbing water from the atmosphere, and that their relative fertility may be estimated by this circumstance alone. Sir Humphrey Davy compared together the absorbent power of various soils with

respect to the moisture of the atmosphere, and found it to be the greatest in the most fertile. Thus, 1000 parts of a celebrated soil from Ormiston in East Lothian, when dried at 212° , gained in an hour, when exposed to air saturated with moisture at the temperature of 62° , 18 grains.

1000 parts of a very fertile soil from the banks of the river Parret in Somersetshire, under the same circumstances, gained 16 grains.

1000 parts of a soil from Mersea in Essex, worth 45s. an acre, gained 13 grains.

1000 parts of a fine sand from Essex, worth 28s. an acre, gained 11 grains.

1000 parts of a coarse sand, worth 15s. an acre, gained only 8 grains.

1000 parts of the soil of Bagshot-heath gained only 3 grains.

It is an error, however, to hold that the relative fertility of soils may be determined by their power, under the circumstances mentioned, to absorb moisture from the atmosphere. The power of soils to retain moisture when absorbed, and thus to supply it in due quantity to the plant, is also to be taken into the account. Peat-earth is a very absorbent soil, but it is not a soil of great fertility. It parts with the moisture absorbed with too great facility. Besides, to infer that the fertility of soils depend upon their powers either to absorb or to retain moisture, were to reason as if these were the only conditions of fertility in soils, which does not appear to be the case; and other experiments accordingly do not bear out the conclusion that the fertility of soils depend upon these properties. But this may be inferred, that all productive soils have a considerable power of absorbing moisture, and retaining it when so absorbed, and that the property does not depend on the prevalence of any one substance, but on a mixture of several substances.

It has been found also, we have seen, that the

fertility of soils, however produced, is not dependant on the prevalence of any one mineral in the soil, but on a mixture or combination of several. But what the precise proportion of these is which is the most favourable to fertility, has not yet been determined.

Without detailing any of the numerous experiments of chymical analysis that have been made with the design of ascertaining this and other points relating to the properties of soils, the following conclusions may be given as apparently deducible from the investigations that have taken place :

1. Soils in which the largest quantity of silica and alumina exist in the state of impalpable division are, *cæteris paribus*, the most fertile.

2. Soils in which the quantity of silicious sand is large, are comparatively infertile ; while soils in which the sand is fine and only partially silicious, are comparatively fertile.

3. Oxyde of iron exists in all soils, but does not influence their fertility in proportion to its larger or smaller quantity.

4. An excess of the acid combinations of the oxyde of iron, and certain other saline bodies, is hurtful to vegetation.

5. Carbonate of lime exists in the best soils, and generally, though not always, in larger quantity in the better than in the inferior soils.

6. Certain earths possess the power of combining chymically with animal and vegetable matter, and of retaining it for a longer or shorter time. Thus alumina and lime form certain compounds of greater or less insolubility with animal and vegetable matters, while silica will not enter into the same combinations ; and hence it is that aluminous and calcareous soils retain for a longer time the manures applied to them than silicious acids.

7. When water is in excess in the soil, and when vegetable matter is present, acid is formed which

is injurious to the productive powers of the soil. In the first stages the acid appears to be the acetic ; in the latter stages, when the matter of the vegetable is being converted into peat, the acid appears to be the gallic, and the tannin principle is formed.

8. Soils, besides absorbing moisture from the air, appear to absorb carbon and other matters nutritional to plants.

These are the principal results to which the chymistry of agriculture has conducted us with respect to soils. This branch of science, however, may be said to be as yet imperfect, and a large field of useful investigation still remains for the philosophical inquirer. Although it may be said that much has not been done with relation to the really useful, which observation and practice had not before shown, yet we have at least escaped from the errors of former opinions, and so far the path of farther inquiry is more open to us.

Among other results to which this species of investigation has conducted us, we have seen that the practice known to agriculturists, of mixing together different kinds of earths, admits of explanation on principles founded on our knowledge of the composition of soils ; that the beneficial action of manures depends upon a proper constitution and texture of the mineral portion of the soil, and that hence, to derive the full benefit of manures, the province of the cultivator is to improve the texture and constitution of the soil : that the comminution of the component parts of the soil is beneficial, as rendering the whole more pervious to the air, and the vapour, and other matters with which the atmosphere is charged : and further, we have been enabled to render our common nomenclature of soils more precise, by distinguishing them by the terms silicious, aluminous, calcareous, magnesian, and ferruginous, as silica, alumina, lime, magnesia, and oxyde of iron, prevail in their composition.

We might now proceed to consider the relation existing between the soil of a country and its geological condition. This is a subject interesting to the scientific agriculturist. But, however curious the investigation might prove, it is not necessary for that practical illustration of the subject of soils which consists with the design of this work. Besides, to characterize the quality of soils, as affected by the geological nature of the country or district, is to view the subject in a somewhat more extended manner than is consistent with the common purposes of the farmer. Although it is found that a relation may be generally traced between the nature of the rocks of a country or district and its fertility—as in the British Islands, between the new red sandstone and the finest districts of the country; between the coal formation under certain circumstances, and a ferruginous and somewhat ungrateful soil; between the magnesian limestone and a tract of comparative infertility; between the lias formation and one of comparative productiveness, and so on—yet many degrees of quality may exist in the soils of the same series of rocks and in the same country; and even all the contrast between great fertility and great barrenness may be found within the limits of a single field. We must therefore narrow our views when we examine the soils which we have occasion to cultivate, and regard, not their properties with relation to an entire district, but their minuter shades of fertility and character.

We have thus considered their properties as determined by their external characters, and in part by their chymical composition. We may now consider their characters as determined by their vegetable productions.—*Low's Elements of Practical Agriculture.*

CHAPTER III.

The Properties of Soils, as determined by their Vegetable Productions.

WHEN we regard the distribution of plants in different regions, we perceive that this is determined by causes which have little relation to the nature of the soil on which the plants grow. The soils of all countries are, in their essential characters, alike. The same mineral masses, composed of the same substances, exist over all the world, and yield, by their disintegration or decomposition, the same materials for the forming of soils.

But, although the mineral matter of the soils of all countries is thus similar in its constituent parts, it is altogether different with the vegetation by which these soils are characterized. Every zone, from the equator to the polar circle, is distinguished by a different vegetation, and different regions have their peculiar plants. A district of granite, of sandstone, or trap, in southern Asia, will yield the same materials for forming soils as similar districts in northern Europe, while the vegetation produced will scarcely seem to possess any common character.

Among the natural causes which effect the vegetation of countries, the influence of temperature is that which is the most obvious to the senses. When we pass from a warm country to a cold, we perceive a change in the whole character of the vegetation. We cannot ascend a mountain without finding such a change in the kinds of plants produced, and in the vigour with which they grow, dependant upon the change of temperature. The

degree of moisture, too, the distance or proximity of the sea, and other circumstances connected with the climate and physical condition of the country, affect the nature of its vegetable productions, and show that the influence of soil, with respect to the kinds of plants produced, is entirely subordinate to that of temperature and effects of climate.

When we extend, then, the range of our observation to different and distant countries, we see that the nature of the plants cannot indicate that of the soils on which they grow. It is only within narrow limits, and under given conditions of climate, that the kinds of plants afford any indication of the nature of the soils which produce them.

Within certain geographical limits, however, as those of a country having throughout nearly the same climate with respect to temperature and humidity, useful rules may be given for distinguishing soils by means of the plants which they produce. Numerous species of plants, indeed, will grow with equal readiness on different kinds of soil; yet there are other species which affect particular soils, and in their wild state do not grow on any other. Thus, there are plants whose natural habitat is peat, others which grow on soils charged with moisture, and others on soils which are dry; some which, under the like conditions of humidity and temperature, are proper to the light and silicious soils, some to the stiff and aluminous, some to the calcareous.

But as, even within the limits of a single country, pretty similar in its climate throughout, variations must exist of altitude, and, consequently, of temperature—of exposure to particular winds, and, consequently, of humidity; of proximity or distance from the sea, and other circumstances affecting the habits of plants—it is often difficult to indicate the precise nature of a soil merely by its prevailing vegetation. It is almost always possi-

ble, however, to determine from this circumstance whether the soil be wet or dry, and whether it be fertile or infertile.

It is for the last-mentioned purpose, namely, determining the character of a soil with respect to its fertility, that the examination of its vegetable produce is the most important in practice. The nature of a soil, with regard to its texture and composition, will generally be best determined by an examination of the substance itself. But its fertility or power of production may be judged of from its natural produce; in part from the kinds of plants which are peculiar to it, and in part from the luxuriance with which they grow.

When we cast the eye over a tract of country, we have generally little difficulty in determining whether this tract be barren or fertile. The general aspect of the vegetation, whether stunted or vigorous; the absence or presence of heaths; the richness of the sward; the cleanness and straightness of the stems of trees; the verdure of the foliage, and the like, present to the eye a general character not readily mistaken.

When we observe a tract covered with luxuriant grasses and other plants, and with vigorous shrubs and trees, we naturally associate these appearances with fertility in the soil itself. When, again, we see a tract of heaths or naked sands, with the plants small or sickly, the soil thinly covered with lichens, mosses, and other inferior plants, the eye alone is sufficient to indicate that the tract is absolutely or relatively infertile.

The same method of judging of the productiveness of the soil may be extended to a field or to a farm. Let us direct the eye over it, and its general character with relation to its vegetable productiveness will impress us at once with an idea of its fertility or barrenness.

This conclusion indeed, will not be so securely

arrived at if the surface be limited to a single field, and still less if that field shall be cultivated; in which case effects of art, and the stimulus of cultivation, may disguise the natural characters of the soil. But if the range of our observation shall be so extended as to take in a sufficient number of fields and objects, as trees, shrubs, hedges, and natural meadows, we shall scarcely fail, if the eye be at all accustomed to country objects, to arrive at a tolerably correct conclusion as to the general character of the soil in respect to fertility; and our conclusions will be yet more satisfactory and precise if we know the particular kinds of plants which thus give the character of infertility or productiveness to the soil.

The plants the most important in this species of examination are the heaths, the grasses, and other herbage plants. In the vast forests of the New World, the most common method resorted to by settlers for judging of the comparative productiveness of soils, is by observing the kinds of trees produced, whether pine, cedar, hickory, or oak. This is because the principal vegetable productions of these countries are wood. But with us the principal vegetable productions are the heaths, the grasses, and other plants that form the sward. These may be said to cover the entire surface of the country when not extirpated by art; and they afford, accordingly, the readiest means which vegetable productions present, of judging of the properties of soils.

The fertility of soils, generally speaking, is denoted by their power to yield the useful plants; and it is a law, with few exceptions, that the poorer the soil is, the less nutritious are the plants which, in its natural state, it produces. The soils of the poorest class produce mosses, lichens, and heaths, which are less nutritious than the grasses. As the soil improves in quality, the grasses become inter-

mixed with the heaths, lichens, and mosses. But these grasses are still inferior and little nutritious. As the soil continues to improve, the grasses become more valuable in their kind and more numerous in their species; and, in like manner, the leguminous and other herbage plants indicate, by their kinds and greater numbers, the increasing fertility of the soil. A square foot of rich old turf has been found to contain 1000 separate plants of twenty distinct species;* while a square foot of silicious sand will frequently contain not more than half a dozen distinct plants, and those of a single species.

In the northern latitudes of Europe, the plants most generally regarded as indicative of inferior soils are the heaths. Some of the species of this family characterize, in a peculiar manner, the soils termed peaty. They are found, too, abundantly on the coarser clays or tills, on the poorer silicious sands, as those lying upon or derived from quartz, on the poorer classes of calcareous soils, as chalk, and generally on all soils low in the scale of fertility.

The soils where this kind of plant prevails are frequently termed heathy soils or heaths. Heathy soils have, however, their relative degrees of productiveness, and this is generally well denoted by the vigour with which the heaths peculiar to them grow. Thus, a soil of stunted heaths may be regarded as the lowest in the scale of fertility, while a vigorous growth of the plant may indicate a soil susceptible of improvement and cultivation.

[We omit here the names of many plants which indicate the quality of the soil, as several of them are not found in the United States, and of those that are, little is known, by common readers, of their botanical or common names.]

* Hort. Gram., Woburnensis.

Various plants are regarded as indicating fertility where they prevail. Of these are :

1. *Cnicus lanceolatus*—Spear Plume-Thistle.
2. *Urtica dioica*—Great Nettle.
3. *Arctium Lappa*—Common Burdock.
4. *Stellaria media*—Common Chickweed.
5. *Achillea Millefolium*—Common Yarrow.

And, generally speaking, all the richer and more nutritious pasture grasses. Such are :

1. *Dactylis glomerata*—Rough Cocksfoot.
2. *Festuca pratensis*—Meadow Fescue.
3. *Alopecurus pratensis*—Meadow Foxtail.
4. *Poa trivialis*—Rough-stalked Meadow-grass.
5. *Phleum pratense*—Meadow Catstail.
6. *Lolium perenne*—Rye-grass.

Those who desire to pursue this investigation more in detail, may consult botanical works descriptive of the plants of particular countries or districts, in which they will find the habitats of plants indicated with more or less correctness. It is not necessary, in the present place, to extend the observations on this subject ; for, in giving examples of plants, those have been selected which are of frequent occurrence, and the best suited to indicate the characters of soils in this country.

I shall now conclude the subject of soils by giving the student a few rules for enabling him to distinguish soils in the situation in which they may be presented to him.

First, then, let him make such use of the indications afforded by the natural produce of the soils as his means of information afford. He may not know the names of the plants that are growing naturally upon the surface, but he can always observe whether they are growing with vigour, whether the sward is thickly covered with species, and whether the general aspect of the part to be examined indicates fertility or poverty.

A difficulty, which it will be well that he endeav-

our, in the first place, to overcome, is to distinguish the peaty soils from the earthy. He will experience little difficulty in this when they are distinct from each other, and covered by their natural herbage. But when they are subjected to cultivation, or intermingled with the earthy soils of the same field, or when a soil contains a certain portion of peat in its composition, without being entirely peaty, then the eye may be deceived from their resemblance to the dark-coloured loams. The one class of soils, however, may be of great fertility, and the other of great barrenness; for it is to be observed that, though peat may be often rendered fertile, its presence in soils is always suspicious.

The soils termed peaty, it was before observed, are dark in their colour, and loose and spongy in their texture, even when improved by art. The soils which they most resemble in external characters are the richer loams, but they are more light and spongy than these, and their colour is of a duller dark than the loams, which approach rather to a hazel hue. Peaty soils, too, very generally lie on a retentive subsoil; but perhaps the best method of discriminating them, in the absence of their peculiar vegetation, is by the stones which lie upon their surface. These appear to be acted upon by the acid matter of the peat, and present a white appearance, which, when once observed, will not be easily mistaken again. Coupling this indication with the dull black, as distinguished from the brighter hazel of the loam, and, above all, with the peculiar vegetation and sterile aspect of the surface, the student will soon learn to distinguish the peaty soils from the earthy.

In examining the earthy soils, an essential circumstance to be regarded, is the depth of the soil and the texture of the subsoil. A medium depth of a soil may be held to be from nine to ten inches. But it will be better that it exceed a foot, and this

greater depth of the soil is always a favourable indication. If the depth of the soil does not exceed six inches, that is an unfavourable indication. Such shallow soils are rarely good, except sometimes when they occur resting on peculiar rocks, as compact limestone, and certain easily decomposed basalts and porphyries. If a shallow soil shall occur on a retentive clay or on silicious sand, we may certainly pronounce it to be bad. When, in the common operations of tillage, the plough is constantly turning up a subsoil very different in colour to the upper stratum, that is an unfavourable indication.

When we find the rain, in a furrow of ordinary descent, carrying off the soil and leaving the subsoil exposed, that is an unfavourable indication. It is desirable to see the water in the furrows sink down and be absorbed, instead of carrying off the surface soil.

If the soil be of a dull black colour, and if it present upon the surface the white stones above referred to, that is an unfavourable indication, as it shows that the soil has more or less of peat in its composition.

If the soil produce sub-aquatic plants, it is wet. If we find that such a soil is peaty or shallow on a retentive subsoil, it is naturally steril. If we find that the sub-aquatic plants are tall and vigorous, and the soil earthy and deep, the removal of the wetness may remove the cause of infertility, and such a soil may become of the richest kind.

If we find a soil producing, naturally, the superior herbage plants, and of a good depth, that soil we may infer to be good. When soil of this kind tends to a dark hazel colour, we may safely reckon it among the superior soils.

By attention to these rules, and by a little observation and practice, the difficulty of discriminating soils will gradually be lessened, and at length dis-

appear. Those who have been used to country objects rarely experience difficulty in distinguishing soils, in so far, at least, as these soils are to be distinguished by their texture into stiff and free, or by their powers of production into rich and poor.—*Low's Elements of Practical Agriculture.*

CHAPTER IV.

Uses of Soils to Vegetables.

Soils afford to plants a fixed abode and medium of nourishment.—Earths, exclusive of organized matter (animal and vegetable substances) and water, are allowed by most physiologists to be of no other use to plants than that of supporting them, or furnishing a medium by which they may fix themselves to the globe. But earths and organic matters, that is, soils, afford at once support and food.

The pure earths merely act as mechanical and indirect chymical agents in the soil.—The earths consist of metals united to oxygen (a constituent of the atmosphere), and these metals have not been decomposed: there is, consequently, no reason to suppose that the earths are convertible into the elements of organized compounds, that is, into carbon, hydrogen, and azote (three substances which make up the bulk of all plants). Plants have been made to grow in given quantities of earth. They consume very small portions only; and what is lost may be accounted for by the quantities found in the ashes: that is to say, it has not been converted into any new product. The carbonic acid united to lime or magnesia, if any stronger acid happens to be found in the soil during the fermentation of vegetable

matter, which will disengage it from the earths, may be decomposed; but the earths themselves cannot be supposed convertible into other substances by any process taking place in the soil. In all cases the ashes of plants contain some of the earths of the soil in which they grew; but these earths, as has been ascertained by the earths afforded by different plants, never equal more than one fiftieth of the weight of the plant consumed. If they be considered as necessary to the vegetable, it is as giving hardness and firmness to its organization. Thus it has been mentioned that wheat, oats, and many of the hollow-stalked grasses have an epidermis [outer bark] principally of silicious earth, the use of which seems to be to strengthen them, and defend them from the attacks of insects and parasitical [which grow and feed upon others] plants.

The true nourishment of plants is water and decomposing organic matter [rotted vegetable and animal substances].—Both these exist in soils, not in pure earths: but the earthy parts of the soil are useful in retaining water, so as to supply it in the proper proportions to the roots of the vegetables; and they are likewise efficacious in producing the proper distribution of the animal or vegetable matter. When equally mixed with it they prevent it decomposing too rapidly, and by their means the soluble parts are supplied in proper proportions.

The soil is necessary to the existence of plants, both as affording them nourishment, and enabling them to fix themselves in such a manner as to obey those laws by which their radicles are kept below the surface, and their leaves exposed to the free atmosphere. As the system of roots, branches, and leaves is very different in different vegetables, so they flourish most in different soils; the plants that have bulbous roots require a looser and lighter soil than such as have fibrous roots; and the plants pos-

sessing only short fibrous radicles demand a firmer soil than such as have tap-roots or extensive lateral roots.

The constituent parts of the soil which give tenacity and coherence are the finely-divided matters, and they possess the power of giving those qualities in the highest degree when they contain much alumina. A small quantity of finely-divided matter is sufficient to fit a soil for the production of turnips and barley, and a tolerable crop of turnips has been produced on a soil containing eleven parts out of twelve sand. A much greater proportion of sand, however, always produces absolute sterility. Vegetable or animal matters, when finely divided, not only give coherence, but likewise softness and penetrability: but neither they nor any other part of the soil must be in too great proportion; and a soil is unproductive if it consists entirely of impalpable matters. Pure alumina or silica, pure carbonate of lime, or carbonate of magnesia, are incapable of supporting healthy vegetation; and no soil is fertile that contains as much as nineteen parts out of twenty of any of these constituents.

A certain degree of friability or looseness of texture is also required in soils, in order that the operations of culture may be easily conducted; that moisture may have free access to the fibres of the roots; that heat may be readily conveyed to them; and that evaporation may proceed without obstruction. These are commonly attained by the presence of sand. As alumina possesses all the properties of adhesiveness in an eminent degree, and silex those of friability, it is obvious that a mixture of these two earths, in suitable proportions, would furnish everything wanted to form the most perfect soil as to water and the operations of culture. In a soil so compounded water will be presented to the roots by capillary attraction. It will be suspended in it in the same manner as it is suspended in a sponge:

not in a state of aggregation, but minute division; so that every part may be said to be moist, but not wet.

The power of the soil to absorb water by cohesive attraction depends, in great measure, upon the state of division of its parts; the more divided they are, the greater is their absorbent power. The different constituent parts of soils likewise appear to act, even by cohesive attraction, with different degrees of energy. Thus, vegetable substances seem to be more absorbent than animal substances; animal substances more so than compounds of alumina and silica; and compounds of alumina and silica more absorbent than carbonates of lime and magnesia: these differences may, however, possibly depend upon the differences in their state of division, and upon the surface exposed.

The power of soil to absorb water from air is much connected with fertility. When this power is great, the plant is supplied with moisture in dry seasons, and the effect of evaporation in the day is counteracted by the absorption of the aqueous vapour from the atmosphere by the interior parts of the soil during the day, and by both the exterior and interior during the night. The stiff clays approaching to pipe clays in their nature, which take up the greatest quantity of water when it is poured upon them in a fluid form, are not the soils which absorb most moisture from the atmosphere in dry weather. They cake, and present only a small surface to the air; and the vegetation on them is generally burned up almost as readily as on the sands. The soils which are most efficient in supplying the plant with water by atmospheric absorption, are those in which there is a due mixture of sand, finely-divided clay, and carbonate of lime, with some animal or vegetable matter, and which are so loose and light as to be freely permeable to the atmosphere. With respect to this quality, carbonate of lime and animal

and vegetable matter are of great use in soils : they give absorbent power to the soil without likewise giving it tenacity ; sand, which also destroys tenacity, on the contrary gives little absorbent power. The absorbent power of soils, with respect to atmospheric moisture, is always greatest in most fertile soils ; so that it affords one method of judging of the productiveness of land.

As examples of the absorbent powers of soils, one thousand parts of a celebrated soil from Ormiston, in East Lothian, which contained more than half its weight of finely-divided matter, of which eleven parts were carbonate of lime and nine parts vegetable matter, when dried at two hundred and twelve degrees, gained in an hour, by exposure to the air, saturated with moisture, at a temperature of sixty-two degrees, eighteen grains. One thousand parts of a very fertile soil from the banks of the river Parret, in Somersetshire, under the same circumstances, gained sixteen grains. One thousand parts of a soil from Mersea, in Essex, gained thirteen grains. One thousand grains of a fine sand from Essex gained eleven grains. One thousand of a coarse sand gained only eight grains. One thousand of a soil of Bagshot Heath gained only three grains.—*Griesenthwaite.*

CHAPTER V.

Means of Increasing the Productive Powers of Soils

THE means at our command of increasing the productive powers of soils may be comprehended under the following general heads :

1. Supplying to the soil those organic and earthy substances which may be required.
2. Altering its texture, depth, and properties, by tillage and other means.
3. Changing its relation with respect to moisture.
4. Changing its relation with respect to temperature.

Vegetable and animal matters, in a decomposing state, appear to act in various ways in increasing the productive powers of the soil. They improve its texture, and they may be supposed to increase its power to absorb and retain moisture; but, above all, they supply that matter which, in whatever form conveyed to the organs of plants, tends to nourish them. This matter being absorbed by the roots of plants, it must be supplied when exhausted.

Experience has, in every age, accordingly taught the husbandman to supply these substances to the soil; and the doing so forms one of the most important means at his command of maintaining or increasing its fertility.

Besides the animal and vegetable matter which is mixed or combined with the mineral part of the soil and is essential to its productiveness, the mineral parts themselves, it has been seen, require to be mixed together in certain proportions and in certain states of division, in order to produce the greatest degree of fertility.

Silica and alumina form the principal mineral part of the soil. If one or the other of these earths be in excess, the soil is defective in its composition. If the alumina prevails, the soil is too adhesive; if the silica prevails, it is too loose. A medium is seen to be the best; and although the precise proportion in which the alumina and silica should exist have not been determined, it is safer that there be a tendency to an excess of alumina than silica.

Further, the fertility of the soil depends on the state of division, chymical or mechanical, of these minerals.

It would appear, then, to be a means of improving the composition of a soil, to add to it silicious matter when it is found to be too stiff, and aluminous matter when it is found to be too loose; and further, to reduce the substances to their greatest degree of mechanical or chymical division.

Sometimes, accordingly, we have the means of improving the constitution of soils by mixing sand with clay, or clay with sand. But, in practice, the direct mixing of these two substances, for the purpose of producing a soil of better texture, is rare: *first*, because the expense of this species of improvement is considerable; and, *second*, because, in the state in which sand and clay are usually available for this purpose, it seldom happens that the aluminous matter of the one, or the silicious matter of the other, is in that state of minute division which is favourable to fertility.

It is otherwise with earth lime. This can, in all cases, be reduced by heat to that state of minute division which is favourable to the productiveness of soils, and hence can always be applied with benefit to those soils in which it is wanting.

Lime is sometimes mixed, in its natural state, with aluminous and silicious matter. It then forms a marl, a substance which is frequently applied to soils as a means of improving them: it is chiefly to

the lighter soils that lime is applied ; for then is not only lime applied, but alumina, to improve the texture of the soil. It is by means of this mixture that some of the greatest improvements on silicious sands that have taken place in Europe have been effected.

There are cases in which even calcareous matter is in excess in soils. This occurs especially in districts where the chalk formation exists. When the earthy stratum resting upon chalk is very thin, the chalky matter becomes mixed with it, and, being then in excess, forms a barren soil.

An obvious means of amending the composition of a soil of this kind, is by adding any of the other earths, whether silicious or aluminous. We need not here scruple to apply them because the clay is coarse or the sand silicious. We may add them in almost any form in which they can be conveniently procured ; for the effect will be to improve the composition of the soil.

There is another case in which, in like manner, silicious and aluminous matter may be applied, directly, in almost any state in which it may be found. This is in the case of peat. Here the vegetable matter is in excess, and the addition, accordingly, of any other earths is an amendment of the composition of the soil.

We see, then, that the composition of soils may be improved by the addition of animal and vegetable matter, and also in many cases by the addition of the earths in which they may be deficient, and in an especial degree of lime, which we can always apply in the form of minute division best suited to improve the composition of the soil. This is the first of the means referred to of adding to the productive power of soils, and will be considered in detail under the head Manures, and other divisions of the management of the farm.

The *second* means referred to of increasing the

productive power of a soil, is altering its texture, depth, and properties, by tillage and other means.

The mere effect of that comminution of the parts of soil which it undergoes in the common operations of tillage, is seen to have a beneficial influence on the productive powers of the soil. Whether the soil imbibes from the atmosphere anything but aqueous vapour or not, it is known that the exposure of the matter of the soil to the atmosphere, and the comminuting of its parts by tillage, add permanently to its fertility. Thus we learn from experience the good effects of tilling lands well; soils once tilled are rendered, for the most part, more productive by the process. Peaty turf, if suffered to remain in its original state, may continue to produce nothing but heath and the most useless plants; but, if merely ploughed and exposed to the influence of the atmosphere, it will at once tend to produce grasses of a better kind and of greater variety; and, again, if a subsoil of coarse clay be exposed to the atmosphere for the first time, it is generally at the first very unproductive, and it is not until after long exposure to the air that it becomes productive. This is most remarkable in the case of clay marl, a substance, in itself, containing the materials of a fertile soil, but which is often barren until after pulverization and the influence of the atmosphere.

It is, indeed, conformable to analogy, as well as to experience, that soils should be improved by pulverization and exposure to the atmosphere. In our examination of the constituent parts of soils, we have seen that their fertility is in a great degree indicated by the proportion of minutely divided earthy matter which they contain.

The effect of tillage, therefore, may be reasonably supposed to promote this division, both by the mechanical action of our instruments, and by exposing the particles of the earth to the action of the air.

Another object sometimes produced by tillage, and subservient to the amendment of the soil, is the deepening of the upper stratum.

The subsoil, it has been seen, is distinguished from the soil, so called, by its containing less vegetable and animal matter, and so being less suited to the nourishment of plants; and in many cases it is even found to be injurious to vegetation. It is generally important, however, that there be a good depth of soil, and thus it is often expedient, as a means of effecting a permanent improvement of the surface, to plough up and mix with it a portion of subsoil, even though that subsoil should in itself be infertile.

These, then, are the principal mechanical means by which we can improve the soil, and they will be considered in detail, under the various heads which relate to the operations of tillage.

Another means, indeed, of changing the composition of soils is incineration, commonly called *paring and burning*. This process will be described as connected with the operations of tillage, and may be considered as one of the mechanical means possessed by us of adding to the productiveness of the soil.

The *third* means referred to, of adding to the productive power of soils, is changing their relation with respect to moisture.

In warmer countries, the soil is comparatively little injured by an excess of water, and more frequently suffers from the insufficiency of it. In climates like that of Britain, however, the operation of conveying away the water which is in excess is an essential one, and, if neglected, the devised scheme of improvement may fail. The surplus water is either stagnant upon the surface, or penetrates below the surface. The freeing of cultivated land of water upon the surface gives rise for the formation of land into ridges, by which the water escapes

without stagnating upon the ground, or sinking into the subsoil below. This is an object necessarily connected with tillage, and will be described when the manner of cultivating land is treated of.

The freeing of the soil again from that superfluous water which is contained below the surface, forms a peculiar branch of agricultural improvement, and will be described under the head of Draining.

As draining is more required in colder countries, so irrigation, or the watering of land, is less required in those countries where the heat and evaporation are greater. Irrigation, however, is a curious and interesting branch of rural economy, derived by us from very ancient times. In this country it is chiefly employed in watering the lands in grass during the months of winter and spring.

The last of the means referred to, of adding to the productive power of soils, is by changing the relation with respect to temperature.

This means of adding to the productive power of soils is less within our control than any of the others. It is only by slow degrees that we can improve the climate of a country. It is chiefly by draining, and the raising of hedges and wood; all of these, accordingly, form important objects of rural economy, and will be partially treated of in this work.

The means, then, of adding to the productive powers of the soil, namely, supplying the organic and earthy substances which may be required; altering its texture, depth, and properties, by mechanical means, and changing its relation with respect to moisture, will all be treated of under the different divisions of our subject; and we shall begin with that which is most closely connected with the nature and property of soils, the nature and property of those substances which we apply to the soil under the name of manures.—*Low's Elements of Practical Agriculture.*

CHAPTER VI.

Supply of Food to Plants by Manure and Culture.

WITH regard to the food of plants derived from the atmosphere, the supply is pretty regular, at least in as far as the gases are concerned; for they are not found to vary materially in their proportions on any part of the surface of the globe; but the quantity of moisture contained in the atmosphere is continually varying, so that in the same season you have not always the same quantity, though in the course of the year the deficiency is perhaps made up. From the atmosphere, therefore, there is a regular supply of vegetable food kept up by nature for the support of vegetable life, independent of the aid of man: and if human aid were even wanted, it does not appear that it would be of much avail. But this is by no means the case with regard to soils; for if soils are less regular in their composition, they are at least more in the reach of human management. The supply of food may be increased by altering the mechanical or chymical constitution of soils; and by the addition of food in the form of manures. The mechanical constitution of soils may be altered by pulverization, consolidation, draining, and watering; their chymical properties by aeration and torrifaction; both mechanical and chymical properties, by the addition of earths and other substances; and manures, either liquid or solid, are supplied by irrigation and distribution of dungs and other nourishing matters, with or without their interment.

Soils in a state of culture, though consisting originally of the due proportion of ingredients, may yet

become exhausted of the principle of fertility, by means of too frequent cropping; whether by repetition or rotation of the same, or of different crops. In this case, it should be the object of the practical cultivator to ascertain by what means fertility is to be restored to the exhausted soil or communicated to a new one. In the breaking up of new soils, if the ground has been wet or marshy, as is frequently the case, it is often sufficient to prepare it by means of draining off the superfluous and stagnant water, and of paring and burning the turf upon the surface. If the soil has been exhausted by a too frequent repetition of the same crop, it often happens that a change of crop will answer the purpose of the cultivator; for although a soil may be exhausted by one sort of grain, it does not necessarily follow that it is also exhausted for another. And, accordingly, the practice of the farmer is to sow his crops in rotation, having in the same field, perhaps, a crop of wheat, barley, beans, and tares in succession; each species selecting in its turn some peculiar nutriment, or requiring, perhaps, a smaller supply than the crop that preceded it. But even upon the plan of rotation, the soil becomes at length exhausted, and the cultivator is obliged to have recourse to other means of restoring fertility. In this case an interval of repose is considerably efficacious, as may be seen from the increased fertility of fields that have not been ploughed up for many years, such as those used for pasture, or even from the walks and paths in gardens where they are again broken up. Hence, also, the practice of fallowing, and of trenching or deep ploughing, which, in some cases, has nearly the same effect.

The fertility of a soil is restored, in the case of draining, by means of its carrying off all such superfluous moisture as may be lodged in the soil, which is well known to be prejudicial to plants not naturally aquatics, as well as by rendering the soil

more firm and compact. In the case of burning, the amelioration is effected by means of the decomposition of the vegetable substances contained in the turf, and subjected to the action of the fire, which disperses also a part of the superfluous moisture, but leaves a residue of ashes favourable to future vegetation. In the case of the rotation of crops, the fertility is not so much restored as more completely developed and brought into action; because the soil, though exhausted for one species of grain, is yet found to be sufficiently fertile for another; the food necessary to each being different, or required in less abundance. In the case of the repose of the soil, the restored fertility may be owing to the decay of vegetable substances that are not now carried off in the annual crop, but left to augment the proportion of vegetable mould; or to the accumulation of fertilizing particles conveyed to the soil by rains; or to the continued abstraction of oxygen from the atmosphere. In the case of fallows, it is owing undoubtedly to the action of the atmospheric air upon the soil, whether in rendering it more friable, or in hastening the putrefaction of noxious plants, or it is owing to the abstraction and accumulation of oxygen. In the case of trenching or deep ploughing, it is owing to the increased facility with which the roots can now penetrate to the proper depth, and thus their sphere of nourishment is increased. But it often happens that the soil can no longer be ameliorated by any of the foregoing means, or not at least with sufficient rapidity for the purposes of the cultivator; and in this case there must be a direct and actual application made to it of such substances as are fitted to restore its fertility. Hence the indispensable necessity of manures, which consist principally of animal and vegetable remains that are buried, and finally decomposed in the soil, from which they are afterward absorbed by the roots of the plant in a state of solution.

Plants are nourished in some degree analogous to the animal economy.—The food of plants, whether lodged in the soil or wafted through the atmosphere, is taken up by intromissions, in the form of gases or other fluids. It is there known as their sap; this sap ascends to the leaves, where it is elaborated as the blood of animals is in the lungs; it then enters into the general circulation of the plant, and promotes its growth [of the roots as well as of the branches seeds and fruits.]—*Encyclopedia of Agriculture.*

CHAPTER VII.

Pulverization of Soils.

The mechanical division of the parts of soil is a very obvious improvement, and applicable to all in proportion to their adhesive texture. Even a free silicious soil will, if left untouched, become too compact for the proper admission of air, rain, and heat, and for the free growth of the fibres; and strong upland clays, not submitted to the plough or spade, will in a few years be found in the possession of fibrous-rooted perennial grasses, which form a clothing on their surface, or strong, tap-rooted trees, as the oak, which force their way through the interior of the mass. Annuals and rementaceous-rooted herbaceous plants cannot penetrate into such a soil.

The first object of pulverization is to give scope to the roots of vegetables, for without roots no plant will become vigorous, whatever may be the richness of the soil in which it is placed. The fibres of the roots take up the extract of the soil by in-

troususception. The quantity taken up, therefore, will not depend alone on the quantity in the soil, but on the number of absorbing fibres. The more the soil is pulverized, the more the fibres are increased, the more extract is absorbed, and the more vigorous does the plant become. Pulverization, therefore, is not only advantageous previous to planting and sowing, but also during the progress of vegetation, when applied in the intervals between the plants.

[Hence the utility of using the harrow and cultivator, in rowed crops, as corn, potatoes, ruta бага, &c., even when there are no weeds to be destroyed or hilling required; and hence the utility of using the harrow, in spring, upon winter grain.]

Pulverization increases the capillary attraction, or spongelike properties of soils, by which their humidity is rendered more uniform. It is evident this capillary attraction must be greater where the particles of the earth are finely divided; for gravels and sands hardly retain water at all, while clays, not opened by pulverization or other means, either do not absorb water, or when, by long action, it is absorbed, they retain too much. Water is not only necessary to the growth of plants as such, but it is essential to the production of extract from vegetable matters which they contain; and unless the soil, by pulverization or otherwise, is so constituted as to retain the quantity of water requisite to produce this extract, the addition of manures will be in vain. Manure is useless in vegetation till it become soluble in water, and it would remain useless in a state of solution, if it so abounded as wholly to exclude air, for then the fibres or mouths, unable to perform their functions, would soon decay and rot off. Pulverization in a warm season is of great advantage in admitting the nightly dews to the roots of plants. Chaptal relates the great benefit he found in the practice in this respect to his corn

crops; and shows of what importance it is in the culture of vineyards in France.

The temperature of a soil is greatly promoted by pulverization.—Earths, Griesenthwaite observes, are also among the worst conductors of heat with which we are acquainted, and, consequently, it would be a considerable time before the gradually increasing temperature of spring could communicate its genial warmth to the roots of vegetables, if their lower strata were not heated by some other means. To remove this defect, which always belongs to a close, compact soil, it is necessary to have the land open, that there may be a free ingress of the warm air and tepid rains of spring.

Pulverization contributes to the increase of vegetable food.—Water is known to be a condenser and solvent of carbonic acid gas, which, when the lands are open, can be immediately carried to the roots of vegetables, and contribute to their growth; but if the land is close, and the water lies on or near the surface, then the carbonic acid gas, which always exists in the atmosphere, and is carried down by the rains, will soon be dissipated. An open soil is also most suitable for effecting those changes in the manure itself, which are equally necessary to the preparation of such food. Animal and vegetable substances, exposed to the alternate action of heat, moisture, light, and air, undergo spontaneous decomposition, which would not otherwise take place.

By means of pulverization a portion of atmospheric air is buried in the soil.—This air, so confined, is decomposed by the water retained in the earthy matters. Ammonia is formed by means of the hydrogen of the water with the nitrogen of the atmosphere; and nitre by the union of oxygen and nitrogen: the oxygen may also unite with the carbon contained in the soil, and form carbonic acid gas and carburetted hydrogen. Heat is given out

during the process, and hence, as Darwin remarks, the great propriety of cropping lands immediately after they have been comminuted and turned over; and this the more especially if manure has been loose, and the interstices filled with air, than afterward, when it becomes compressed with its own gravity, and relaxing influence of rains, and the repletion of the partial vacuums formed by the decomposition of the enclosed air. The advantage of the heat thus obtained in exciting vegetation, whether in a seed or root, especially in spring, when the soil is cold, must be very beneficial.

The depth of pulverization, Sir H. Davy observes, must depend upon the nature of the soil and subsoil. In rich clayey soils it can scarcely be too deep; and even in sands, unless the subsoil contains some principles noxious to vegetables, deep comminution should be practised. When the roots are deep, they are less liable to be injured either by excessive rain or drought; the radicles are shot forth into every part of the soil; and the space from which this nourishment is derived is more considerable than when the seed is superficially inserted in the soil.

Pulverization should, in all cases, be accompanied by the admixture of the parts of soils, by turning them over. It is difficult, indeed, to pulverize without effecting this end, at least by the implements in common use; but if it could be effected it would be injurious, because the difference of gravity between the organized matters and the earths has a constant tendency to separate them, and stirring a soil only by forks and pronged implements, such as cultivators, would, in a short time, leave the surface of the soil too light and spongy, and the lower part too compact and earthy.—*Encyclopedia of Agriculture*.

CHAPTER VIII.

Calcareous Manures.

We have been reading with much interest, and, we believe, profit, "*Ruffin's Essay on Calcareous Manures*," a copy of the second edition of which has been politely forwarded to us by the author. It is a pamphlet of 116 closely printed 8vo. pages; is sold by J. W. Campbell, Petersburg, and Gideon B. Smith, Baltimore, booksellers, at 75 cents the copy, and by the author, at Shellbanks, Va., at a reduced price by the quantity.

Mr. Ruffin is a gentleman of chymical knowledge, a practical farmer, and editor of the *Farmers' Register*, a work replete with valuable information in rural affairs. He seems to be peculiarly fitted, by location, talents, and persevering investigation, for the work he has furnished us; and we think he has succeeded in pointing out the defects which exist in a portion of our soils, and in suggesting the sure means of correcting them. We do not hesitate to say, that the pamphlet will prove a valuable acquisition to any farmer who has a spark of ambition to better his practice; and we hope the author will meet the ample reward, in the sale of the work, which he justly merits, for his patient labours to improve the condition of our husbandry.

The work is divided into three parts, viz., 1, Theory; 2, Practice; and, 3, Appendix. The second part details the author's experiments with calcareous manures upon his farm, and the results, for nearly twenty years. These go to sustain, we think, pretty fully, the theory laid down in the first part. The lands upon which the experiments were

made are somewhat of the character of those which extend from the east end of Long Island to Florida, upon the tide-waters of the Atlantic; and, with the exception that they probably contain more clay, appear to be similar to what are denominated the Albany barrens, Kinderhook plains, and to a large portion of Saratoga county. The natural growth is pines, oaks, and whortleberry bushes, and, when cleared, common sorrel; the soil is destitute of stones, and the earthy matters are, apparently, a deposit from overflowing waters, at a remote period of time. The experiments were made with shell marl, containing 25 to 27 per cent. carbonate of lime, mixed with sand.

We will remark here, that as the calcareous earth is the benefiting property of the marl, other calcareous earths may be substituted; and on sands, clay marls, it is believed, if convenient, may be more profitably applied than shell marl, which latter does not often occur in the interior. Mr. R. gives the following classification of manures, *a* designating its strongest or most valuable agency, *b* the next strongest, and so on.

"Substances which form manures, are either

"*Alimentary*, or serving as food for plants; as feathers, hair, woollen rags, pounded bones (*b*), all putrescent animal and vegetable substances, as dung, stable and farmyard manures (*a*), straw (*a*), green crops ploughed in (*a*).

"*Solvent* of alimentary manures; as quicklime (*a*), potash and soap ley (*a*)? ashes not drawn (*a*)? paring and burning the surface of the soil (*a*).

"*Mordants*, serving to fix other manures in soils; as calcareous earth, including lime become mild by age (*a*), chalk (*a*), limestone gravel (*a*), wood ashes (*b*), fossil shells (*a*), marl (a calcareous clay) (*a*), old mortar.

"*Neutralizing* acids; as all calcareous manures (*b*), quicklime (*b*), potash and soap ley (*b*), wood ashes (*c*).

"*Mechanical*, or improving by altering the texture of soil; as all calcareous manures (c), marl (b), clay, sand, fermenting vegetable manures (b), green manures (b), unfermented litter (b).

"*Stimulating*; as nitre! common salt?

"*Specific*, or furnishing ingredients necessary for particular plants; as sulphate of lime, or gypsum (for clover), phosphate of lime (for wheat), in bones (a), and drawn ashes (a), salt?"

"*Calcareous earth*, or *carbonate of lime*," says Mr. R., "is *lime* combined with *carbonic acid*, and may be converted into pure or quicklime by heat; and quicklime, by exposure to the air, soon returns to its former state of calcareous earth. It forms limestone, marble, chalk, and shells, with very small admixtures of other substances. Thus the term *calcareous earth* will not be used here to include either *lime* in its pure state, or any of the numerous combinations which *lime* forms with the various acids, except that one (*carbonate of lime*) which is beyond comparison the most abundant throughout the world, and most important as an ingredient of soils. Pure *lime* attracts all acids so powerfully, that it is never presented by nature except in combination with some one of them, and generally with the carbonic acid. When this compound is thrown into any stronger acid, as muriatic, nitric, or even strong vinegar, the *lime*, being more powerfully attracted, unites with, and is dissolved by, the stronger acid, and lets go the carbonic, which escapes with effervescence in the form of air. In this manner the carbonate of lime or calcareous earth may not only be easily distinguished by silicious and aluminous earth, but also from all other combinations of lime," p. 9.

We mark another extract from p. 16, with the view of impressing upon the mind of the reader the very important truths which it conveys, and which are seldom duly appreciated by the ordinary farmer.

VOL. I.—H

"All earths, when as pure as they are ever furnished by nature, are entirely barren, as might be inferred from a description of their qualities [described in p. 9]; nor would any addition of putrescent manures enable either of the earths to support healthy vegetable life.

"The mixture of the three earths in due proportions will correct the defects of all; and with a sufficiency of animal or vegetable matter, putrescent, and soluble in water, a *soil* is formed in which plants can extend their roots freely, yet be firmly supported, and derive all the needful supplies of air, water, and warmth, without being hurt by too much of either. Such is the natural surface of almost all the habitable world; and though the qualities and value of soils are as variable as the proportions of their ingredients are innumerable, yet they are mostly so constituted, that no one earthy ingredient is so abundant, but that the texture of the soil is mechanically suited to some one valuable crop; as some plants require a degree of closeness, and others of openness in the soil, which would cause other plants to decline or perish."

After describing the soil, the general characteristics of which we have mentioned, and the state of agriculture in the tide-water district of Virginia, Mr. R. proceeds, in chap. iii., to describe the different capacities of soils for receiving improvement, in which he lays down the following propositions:

"Proposition 1. Soils naturally poor, and such soils reduced to poverty by cultivation, are essentially different in their powers of retaining putrescent manures; and, under like circumstances, the fitness of any soil to be enriched by any manures is in proportion to what was its natural fertility.

"2. The natural sterility of the soil of lower Virginia (and of like soils elsewhere) is caused by such soils being destitute of calcareous earth, and their being injured by the presence and effects of vegetable acid.

"3. The fertilizing effects of calcareous earth are chiefly produced by its powers of neutralizing acids, and of combining putrescent manures with soils, between which there would otherwise be but little chymical attraction.*

"4. Poor and acid soils cannot be improved durably or profitably by putrescent manures, without previously making them calcareous, and thereby correcting the defect in their constitution.

"5. Calcareous manures will give to our worst soils a power of retaining putrescent manures equal to that of the best; and will cause more productiveness and yield more profit than any other improvement practised in lower Virginia."

The defect in many of the pine lands in the interior is not only the want of calcareous, but of argillaceous matter, clay; they lack the adhesive quality which calcareous earth in a measure, but not sufficiently, supplies. The blue and the other clay marls, which are found in many districts to underlay the soil, offer, therefore, the most efficient means of improving our sands. We have occasionally, though not systematically, applied the blue

* "When any substance is mentioned as *combining* with one or more other substances, as different manures with each other or with soil, I mean that a union is formed by chymical attraction, and not by simple mixture. *Mixtures* are made by mechanical means, and may be separated in like manner; but *combinations* are chymical, and require some stronger chymical attraction to take away either of the bodies so united.

"When two substances combine, they both lose their previous peculiar qualities, or *neutralize* them for each other, and form a third substance different from both. Thus, if certain known proportions of muriatic acid, and pure or caustic soda, be brought together, their strong attraction will cause them to combine immediately. The strong corrosive acid quality of the one, and the equally peculiar alkaline taste and powers of the other, will neutralize or entirely destroy each other, and the compound formed is common salt; the qualities of which are strongly marked, but totally different from those of either of its component parts."

clay, containing 25 to 30 per cent. carbonate of lime, on literally blowing sandhills, at the rate of 3 to 4 hundred bushels, or 20 cart-loads, to the acre, and the results fully sustained the high opinions of Mr. R. of the benefits imparted to these soils by calcareous applications. The soil has become more adhesive, sorrel has disappeared, and there is no longer the former marked difference in the products of the hill and the swale. We have often expressed the opinion, produced by these results, that a load of blue clay has been of more permanent benefit to some of our land than a load of putrescent manure. And in passing over the sandy plains which skirt the rich bottoms on the Connecticut river, we have thought that our blue clay was the material wanted to impart to them adhesiveness and fertility, with the aid, however, of putrescent manures, which, after all, afford the only alimentary nourishment to plants.

Calcareous earth is an essential ingredient in all good soils, though much less of it is required than of sand or clay, and may therefore be artificially supplied at comparative small expense. From 20 to 40 cart-loads per acre of clay marl would double, if not quadruple, the value of our light sands. We hope soon to be able to detail some interesting experiments upon marling, by a gentleman of high standing.

In discussing the second proposition, Mr. Ruffin details the results of nineteen chymical examinations of soils, taken from different localities, all from situations which, from their proximity to calcareous rock, were supposed most likely to present highly calcareous soils. In only four of these experiments did he find any finely-divided calcareous earth, and in these but in very small proportions. These experiments show the error of an opinion generally entertained, that the soil in limestone formations always abounds in carbonate of lime.

Where the limestone is hard and in its natural beds, the debris or pulverized portion is often so minute as to form hardly a perceptible constituent. This fact explains the utility of the practice which prevails in Pennsylvania, as communicated to us, by Dr. Darlington, of applying lime on limestone lands. The benefits of the application seem to be twofold: In the form of quicklime it operates as a solvent, and renders soluble the vegetable matter in the soil; and in that of a carbonate, or mild lime, it improves the soil mechanically, and increases its capacity for combining with, and preventing the waste of, putrescent manures. Mr. Ruffin also examined specimens of soils from the western and southern prairies, from localities abounding in shell marl, or soft and decomposing limestone. These gave an abundant proportion of carbonate of lime; and, in some instances, it existed in excess, so as to render the soils steril.

In acid and neutral soils, Mr. Ruffin supposes that carbonate of lime may have originally existed, and that it may have been decomposed, and the lime taken up, by the gradual formation of vegetable acid, until the lime and the acid neutralized and blanched each other, leaving no considerable excess of either. There are several of the vegetable acids, and among them the oxalic, which abound in sorrel, that have a stronger affinity for acids than carbonic acid, and, when coming in contact with carbonate of lime, would, of course, decompose it and unite with the base. These acids, Mr. R. contends, are poisonous to cultivated crops. The burning of newly-cleared lands is so essential to the first crop, that no good return is expected unless there has been "*a good burn;*" and spots of a new fallow which escape the fire are comparatively barren, until the soil has been broken up and ameliorated by atmospheric or other influence. The fire does not add to the vegetable matter in the soil; it diminishes it; but it produces

some chymical change beneficial to the crop, either by the solvent quality of the ashes which it produces, or by neutralizing some noxious property in the soil.

In discussing the 3d and 4th propositions, our author shows that "silicious earths can have no power, chymical or mechanical, either to attract enriching manures, or to preserve them when actually placed in contact;" and that they "give out freely all they have received, not only to a growing crop, but to the sun, air, and water, so as soon to lose the whole;" that "aluminous earth, by its closeness, mechanically excludes those agents of decomposition, heat, air, and moisture, which sand so freely admits;" and that, therefore, although clay lands retain manure longer, they only retain it mechanically. The means by which calcareous earths act as improving manures, are, "*completely preserving putrescent manures from waste, and yielding them freely for use;*" "*their power of neutralizing acids,*" and of "*altering the texture and absorbency of soils.*"

We will close our notice of this valuable work, for the present, with another extract, explaining the author's views of the operation of manures in the soil, which strongly inculcate the propriety of applying dung in its unfermented or partially fermented state, of ploughing it in, and of cropping the ground with hoed plants, which come to maturity in autumn. We propose, however, unless admonished that we are trespassing upon the publisher's rights, to copy some of Mr. Ruffin's experiments with marl, to show to the readers of the Cultivator the positive and important benefits which have resulted from marling, and to serve as a guide, in some measure, to their practice.

"Except the very small proportions of earthy, saline, and metallic matters that may be in animal and vegetable manures, the whole balance of their bulk (and the whole of whatever can feed plants)

is composed of different elements, which are known only in the form of *gases*, into which they must be finally resolved, after going through all the various stages of fermentation and decomposition. So far from sinking in the earth, these final results could not be possibly confined there, but must escape into the atmosphere as soon as they take a gaseous form, unless immediately taken up by the organs of growing plants. It is probable that but a small portion of any dressing of manure remains long enough in the soil to make this final change; and that nearly all is used by growing plants during previous changes, or carried off by air and water. During the progress of the many changes caused by fermentation and decomposition, every soluble product may certainly sink as low as the rains penetrate; but it cannot descend lower than the water, and that, together with the soluble manure, will be again drawn up by the roots of plants. One exception, however, seems probable. Should the soil need draining, to take off water passing beneath the surface, the soluble manure might be carried off by those springs: and this supposed result receives strong confirmation from the complete loss of fertility which is often observed in spots over a foundation that is springy in wet seasons, but which have been kept under tillage, without being drained. We are as yet but little informed as to the particular changes made, and the various new substances successively formed, and then decomposed, during the whole duration of putrescent manures to the soil; and no field for discovery would better reward the investigations of the agricultural chymist. For want of this knowledge, we proceed at random in using manures, instead of being enabled to conform to any rule founded on scientific principles: nor can we hope so to manage manures with regard to their fermentation, the time and manner of application, mixing with other substances, &c., as to enable the

crops to seize every enriching result as soon as it is produced, and to postpone as long as possible the final results of decomposition, which ought to be the ends sought in every application of putrescent manure."

- We cannot close this brief notice without asking the intelligent reader to reflect on the incalculable advantage of scientific husbandry, when combined with practical operations. Mr. Ruffin, we suspect, is self-taught in chymical science; and yet, within his limited sphere of operations, he is teaching invaluable truths, mostly before unknown or unappreciated by his countrymen, which, ere long, may, in all probability, lead to the addition of annual millions to the value of our agricultural products. If such benefits can result from the limited exertions of a single individual, who is able to devote to the subject but a portion of his time, what benefits might the community not expect from the united exertions of twenty such men, specially directed to the subject, in all the departments of husbandry, in a school of Scientific and Practical Agriculture, under the liberal patronage of the state or of associated wealth!

Marl and Lime.—The theory of the constitution of fertile and barren soils having been regularly discussed, it remains to show its practical application in the use of calcareous earth as a manure. If the opinions which have been maintained are unsound, the attempt to reduce them to practice will surely expose their futility; and if they pass through that trial, agreeing with and confirmed by facts, their truth and value must stand unquestioned. The belief in the most important of these opinions (the incapacity of poor soils for improvement, and its cause) directed the commencement of my use of calcareous manures; and the manner of my practice has also been directed entirely by the views which have been exhibited. Yet in every respect the results of practice have sustained the theory of

the action of calcareous manures, unless there be found an exception in the damage which has been caused by applying too heavy dressings to weak lands.

My use of calcareous earth as manure has been almost entirely confined to that form of it which is so abundant in the neighbourhood of our tide-waters, the beds of *fossil shells*, together with the earth with which they are found mixed. The shells are in various states; in some beds generally whole, and in others reduced nearly to a coarse powder. The earth which fills their vacancies, and serves to make the whole a compact mass, in most cases is principally silicious sand, and contains no putrescent or valuable matter other than the calcareous. The same effects might be expected from calcareous earth in any other form, whether chalk, limestone, gravel, wood-ashes, or lime, though the last two have other qualities besides the calcareous. During the short time that lime can remain *quick* or *caustic* after being applied as a manure, it exerts (as before stated) a solvent power, sometimes beneficial and at others hurtful, which has no connexion with its subsequent and permanent action as calcareous earth.

These natural deposits of fossil shells are commonly but very improperly called *marl*. This misapplied term is particularly objectionable, because it induces erroneous views of this manure. Other earthy manures have long been used in England under the name of *marl*, and numerous publications have described their general effects and recommended their use. When the same name is given here to a different manure, many persons will consider both operations as similar, and, perhaps, may refer to English authorities for the purpose of testing the truth of my opinions and the results of my practice. But no two operations called by the same name can well differ more. The process which it

is my object to recommend is simply the *application of calcareous earth, in any form whatever, to soils wanting that ingredient*, and generally quite destitute of it; and the propriety of the application depends entirely on our knowing that the manure contains calcareous earth, and what proportion, and that the soil contains none. In England the most scientific agriculturists apply the term *marl* correctly to a *calcareous clay* of peculiar texture; but most authors, as well as mere cultivators, have used it for any smooth, soapy clay, which may or may not have contained, so far as they knew, any proportion of calcareous matter. Indeed, in most cases, they seem unconscious of the presence, as well as of the importance, of that ingredient, by not alluding to it when attempting most carefully to point out the characters by which marl may be known. Still less do they inquire into the deficiency of calcareous earth in soils proposed to be marled, but apply any earths, which either science or ignorance may have called marl, to any soils within a convenient distance, and rely upon the subsequent effects to direct whether the operation shall be continued or abandoned. Authors of the highest character (as Sinclair and Young, for example), when telling of the practical use and valuable effects of marl, omit giving the strength of the manure, and generally even its nature; and in no instance have I found the ingredients of the soil stated, so that the reader might learn what kind of operation really was described, or be able to form a judgment of its propriety. From all this, it follows that, though what is called *marling* in England may sometimes (though very rarely, I infer) be the same chymical operation on the soil that I am recommending, yet it may also be either applying clay to sand, or clay to chalk, or true marl to either of these soils; and the reader will generally be left to guess, in every separate case, which of all these operations is meant by the

term *marling*. For these reasons, the practical knowledge to be gathered from all this mass of written instruction on marling will be far less abundant than the inevitable errors and mistakes. The recommendations of marl by English authors induced me very early to look to what was here called by the same name, as a means for improvement; but their descriptions of the manure convinced me that our marl was nothing like theirs, and thus actually deterred me from using it, until other views instructed me that its value did not depend on its having "a soapy feel," or on any mixture of clay whatever.

Nevertheless, much valuable information may be obtained from these same works on calcareous manure, or on marl (in the sense it is used among us), but under a different head, viz., *lime*. This manure is generally treated of with as little clearness or correctness as is done with marl; but the reader, at least, cannot be mistaken in this, that the ultimate effect of every application of lime must be to make the soil more calcareous, and to that cause solely are to be imputed all the long-continued beneficial consequences and great profits which have been derived from liming. But, excepting this one point, in which we cannot be misled by ignorance or want of precision, the mass of writings on lime, as well as on calcareous manures in general, will need much sifting to yield instruction. The opinions published on the operation of lime are so many, so various and contradictory, that it seems as if each author had hazarded a guess, and added it to a compilation of those of all who had preceded him. For a reader of these publications to be able to reject all that is erroneous in reasoning and in statements of facts, or inapplicable on account of difference of soil or other circumstances, and thus obtain only what is true and valuable, it would be necessary for him first to understand the subject better than

most of those whose opinions he was studying. It was not possible for them to be correct when treating (as most do) of *lime* as one kind of manure, and every different form of the *carbonate of lime* as so many others. Only one distinction of this kind (as to operation and effects) should be made, and never lost sight of; and that is one of substance still more than of name. Pure or quicklime and carbonate of lime are manures entirely different in their powers and effects. But it should be remembered that the substance which was pure lime when just burned, often becomes carbonate of lime before it is used (by absorbing carbonic acid from the atmosphere); still more frequently before a crop is planted; and probably always before the first crop ripens. Thus it should be borne in mind that the manure spoken of as lime is often at first, and always at a later period, neither more nor less than calcareous earth: that lime, which at different periods is two distinct kinds of manure, is considered in agricultural treatises as only one: and to calcareous earth are given as many different names, all considered to have different values and effects, as there are different forms and mixtures of the substances presented by nature.

But, however incorrect and inconvenient the term *marl* may be, custom has too strongly fixed its application for any proposed change to be adopted. Therefore I must submit to use the word *marl* to mean beds of fossil shells, notwithstanding my protest against the propriety of its being so applied.

The following experiments are reported, either on account of having been accurately made and carefully observed, or as presenting such results as have been generally obtained on similar soils, from applications of fossil shells to nearly six hundred acres of Coggin's Point farm. It has been my habit to make written memoranda of such things; and the material circumstances of these experiments

were put in writing at the time they occurred, or not long after. Some of the experiments were, from their commencement, designed to be permanent, and their results to be measured as long as circumstances might permit. These were made with the utmost care. But, generally, when precise amounts are not stated, the experiments were less carefully made, and their results reported by guess. Every measurement stated, of land or of crop, was made in my presence. The average strength of the manure was ascertained by a sufficient number of analyses, and the quantity applied was known by measuring some of the loads, and having them dropped at certain distances. At the risk of being tedious, I shall state every circumstance supposed to affect the results of the experiments; and the manner of description and of reference necessary to use, will acquire a degree of attention that few readers may be disposed to give, to enable them to derive the full benefit of these details. But, however disagreeable it may be to give them the necessary attention, I will presume to say that these experiments deserve it. They will present practical proofs of what otherwise would be but uncertain theory; and give to this essay its principal claim to be considered useful and valuable.

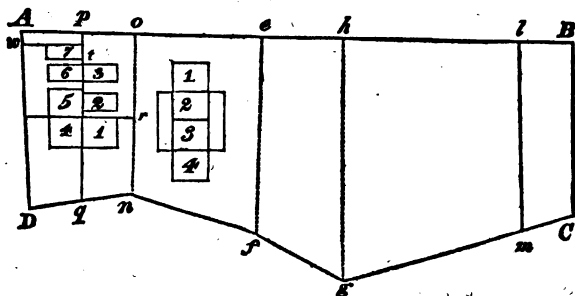
When these operations were commenced, I knew of no other experiments having been made with fossil shells, except two, which had been tried before, and were considered as proving the manure too worthless to be resorted to again. Inexperience, and the total want of any guide, caused my applications, for the first few years, to be frequently injudicious, particularly as to the quantities laid on. For this reason these experiments show what was actually done, and the effects thence derived, and not what better information would have directed as the most profitable course.

The measurements of corn that will be reported
VOL. I.—I

were all made at the time and place of gathering. The measure used for all, except very small quantities, was a barrel holding five bushels when filled level, and which, being twice filled with ears of corn, well shaken to settle them, and heaped, was estimated to make five bushels of grain, and the products will be reported in *grain* according to this estimate. This mode of measurement will serve best for comparing results, but in most cases it is far from giving correctly the actual quantity of dry and sound grain, for the following reasons. The common large soft-grained white corn was the kind cultivated, and which was always cut down for sowing wheat before the best matured was dry enough to grind or even to put up in cribs, and when the ears from the poorest land were in a state to lose considerably more by shrinking. Yet for fear of some mistake occurring if measurements were delayed until the crop was gathered, these experiments were measured when the land was ploughed for wheat in October. The subsequent loss from shrinking would of course be greatest on the corn from the poorest and most backward land, as there most defective and unripe ears would always be found. Besides, every ear, however imperfect or rotten, was included in the measurement. For these several reasons, the actual increase of product on the marl land was always greater than will appear from the comparison of quantities measured: and from the statements of such early measurements, there ought to be allowed a deduction, varying from ten per cent. on the best and most forward corn, to thirty per cent. on the latest and most defective. Having stated the grounds of this estimate, practical men can draw such conclusions as their experience may direct, from the dates and amounts of the actual measurements that will be reported. Some careful trials of the amount of shrinkage in particular experiments will be hereafter stated.

No grazing has been permitted on any land from which experiments will be reported, unless it is especially stated.

Experiments in Marling.—As most of the experiments on new land were made on a single piece of twenty-six acres, a general description or plan of the whole will enable me to be better understood, as well as to be more concise, by references being made to the annexed figure. It forms part of the ridge lying between James River and the nearest stream running into Powell's Creek. The surface is nearly level. The soil, in its natural state, very similar throughout, but the part next to the line BC somewhat more sandy and more productive in corn than the part next to AD; and, in like manner, it is lighter along A *e* than nearer to D *f*. The whole soil, a gray silicious acid loam, not more than two inches deep at first, resting on a yellowish sandy subsoil from one to two feet deep, when it changes to clay. Natural growth mostly pine; next in quantity oaks of different kinds; a little of dogwood and chinquequin; whortleberry bushes throughout in plenty. The quality of the soil is better than the average of ridge lands in general.



Experiment 1.

The part B C *g h*, about 11 acres, grubbed and cut down in the winter of 1814, 15; suffered to lie three years with most of the wood and brush on it. February, 1818, my earliest application of marl was made on B C *m l*, about 2 1-2 acres. Marl 32-100 of calcareous earth, and the balance silicious sand, except a very small portion of clay: the shelly matter finely divided. Quantity of marl to the acre, one hundred and twenty-five to two hundred heaped bushels. The whole B C *g h* coultured, and planted in its first crop of corn.

Results.—1818.—The corn on the marled land evidently much better; supposed difference, forty per cent.

1819.—In wheat. The difference as great, perhaps more so: particularly to be remarked from the commencement to the end of the winter, by the marled part preserving a green colour, while the remainder was seldom visible from a short distance, and by the spring stood much thinner, from the greater number of plants having been killed. The line of separation very perceptible through both crops.

1820.—At rest. During the summer marled all B C *g h*, at the rate of five hundred bushels, without excepting the space before covered, and a small part of that made as heavy as one thousand bushels, counting both dressings. The shells now generally coarse; average strength of the marl, 37-100 of calcareous earth. In the winter after, ploughed three inches deep, as nearly as could be, which made the whole new surface yellow, by bringing barren subsoil to the top.

Results continued.—1821.—In corn. The whole a remarkable growth for such a soil. The oldest (and heaviest) marled piece better than the other, but not enough so to show the dividing line. The average product of the whole supposed to have been fully twenty-five bushels to the acre.

1822.—In wheat; and red clover sowed on all the old marling, and one or two acres adjoining. A severe drought in June killed the greater part of the clover, but left it much the thickest on the oldest marled piece, so as again to show the dividing line, and to yield, in 1823, two middling crops to the scythe; the first that I had known obtained from any acid soil, without high improvement from putrescent manures.

1823.—At rest; nothing taken off except the clover on B C m l.

1824.—In corn; product seemed as before, and its rate may be inferred from the actual measurement on other parts, which will be stated in the next experiment, the whole being now cleared and brought under like cultivation.

Experiment 2.

The part *e f n o*, cleared and cultivated in corn at the same times as the preceding, but treated differently in some other respects. This had been deprived of nearly all its wood, and the brush burned at the time of cutting down; and its first crop of corn (1818) being very inferior, was not followed by wheat in 1819. This gave two years of rest before the crop of 1821; and five years rest out of six since the piece had been cut down. As before stated, the soil rather lighter on the side next to *o e* than *n f*.

March, 1821.—A measured acre near the middle, covered with 600 bushels of calcareous sand (20-100), the upper layer of another body of fossil shells.

Results.—1821.—In corn. October; the four adjoining quarter acres, marked 1, 2, 3, 4, extending nearly across the piece, two of them within and two without the marled part, measured as follows:

Not marled,	No. 1, 6½	} average to the acre 22½ bushels of grain.
"	No. 4, 6½	
Marled,	No. 2, 8½	} average 33½ bushels.
"	No. 3, 8½	

The remainder of this piece was marled before sowing wheat in 1821.

1823.—At rest.

1824.—In corn; distance 5 1-2 by 3 1-4 feet, making 2436 stalks to the acre. October 11th, measured two quarter acres very nearly coinciding with Nos. 2 and 3 in the last measurement. They now made,

No. 2, 7 bushels $3\frac{1}{2}$ pecks, or per acre, 31.1	Average
No. 3, 8 bushels, ... 32.0	
Average in 1821, ...	
	31.2 $\frac{1}{2}$
	33.1

Experiment 3.

The part *e f g h* was cut down in January, 1821, and the land planted in corn the same year. The coultering and after-tillage very badly executed, on account of the number of whortleberry and other roots. As much as was convenient was marled at six hundred bushels (37-100), and the dressing limited by a straight line. Distance of corn 5 1-2 by 3 1-2 feet; 2262 stalks to the acre.

Results.—1821.—October; on each side of the dividing line, a piece of 28 by 21 corn hills measured as follows:

No. 1, 588 stalks, not marled, 2 bushels, equal to . $7\frac{1}{2}$ the acre.
 No. 2, 588 stalks, marled, ... $4\frac{1}{2}$, $16\frac{1}{2}$ the acre.

1822.—In wheat, the remainder having been previously marled.

1823.—At rest. During the following winter it was covered with a second dressing of marl at 250 bushels (45-100), making 850 bushels to the acre altogether.

1824.—In corn. Two quarter acres, chosen as nearly as possible on the same spaces that were measured in 1821, produced as follows:

No. 1, 8 bushels 2 pecks, or to the acre, ...	34
The same in 1821, before marling, ...	7.3 $\frac{1}{2}$
No. 1, 7 bushels $2\frac{1}{2}$ pecks, or to the acre, ...	30.2
The same in 1821, after marling, ...	16.1 $\frac{1}{2}$

1825.—The whole twenty-six acres, including the subjects of all these experiments and observations, were in wheat. The first marled piece in Exp. 1 was decidedly the best, and a gradual decline was to be seen to the latest. I have never measured the product of wheat from any experiment, on account of the great trouble and difficulty that would be encountered. Even if the wheat from small measured spaces could be reaped and secured separately, during the heavy labours of harvest, it would be scarcely possible afterward to carry the different particles through all the operations necessary to show exactly the clean grain derived from each. But, without any separate measurement, all my observations convince me that the increase of wheat from marling is at least equal to that of corn during the first few years, and is certainly greater afterward, in comparison to its product before using marl.

It was from the heaviest marled part of Exp. 1 that soil was analyzed to find how much calcareous earth remained in 1826 (page 26). Before that time the marl and soil had been well mixed by ploughing to the depth of five inches. One of the specimens of the soil then examined consisted of the following parts; the surface, and, consequently, the undecomposed weeds upon it being excluded.

1000 grains of soil yielded

769 grains of silicious sand, moderately fine.

15 " finer sand.

784

8 " calcareous earth, from the manure applied.

189 " finely divided clay, vegetable matter, &c.

28 " lost in the process.

1000

This part, it has been already stated, was originally lighter than the general texture of the land

Experiment 4.

The four arcs marked A D π o were cleared in the winter of 1823, 4. The lines *p q* and *r s* divide the piece nearly into quarters. The end nearest A *p o* is lighter, and best for corn, and was still better for the first crop, owing to nearly that half having been accidentally burned over. After twice coultering, marl and putrescent manures were applied as follows; and the products measured, October 11th, the same year.

	Bushels.	Faths.
<i>s q</i> not marled or manured, produced on a quarter acre (No. 4) of soft and badly-filled corn, 3 bushels, or per acre,	12	
<i>q r</i> and <i>r p</i> , marled at 800 bushels (45-100), by three measurements of different pieces:		
$\frac{1}{2}$ acre (No. 1), 5 bushels, very nearly, or	19	38
$\frac{1}{2}$ acre (No. 2), 2.3 $\frac{1}{2}$	23	2
$\frac{1}{2}$ acre (No. 3), 3.1 $\frac{1}{2}$ } average 24.1 $\frac{1}{2}$	27	
<i>s t</i> manured at 900 to 1100 bushels to the acre, of which $\frac{1}{2}$ acre (No. 5) with rotted cornstalks from winter cowpen gave 5.2 $\frac{1}{2}$.	22	2
$\frac{1}{2}$ acre (No. 6), with stable manure, 4.1 $\frac{1}{2}$.	35	2
$\frac{1}{2}$ acre (No. 7), covered with the same heavy dressings of stable manure, and of marl also, gave 4.2.	36	

p v, marled at 450 bushels, brought not so good a crop as the adjoining *r p* at 800.

The distance was 5 1-2 by 3 3-4 feet. Two of the quarter acres were measured by a surveyor's chain (as were four other of the experiments of 1824), and found to vary so little from the distance counted by corn-rows that the difference was not worth notice.

1825.—In wheat: the different marked pieces seemed to yield, in comparison to each other, proportions not perceptibly different from those of the preceding crop, but the best not equal to any of the land marled before 1822, as stated in the 1st, 2d, and 3d experiments.

1827.—Wheat on a very rough and imperfect sum-

mer fellow. This was too exhausting a course (being three grain crops in the four-shift rotation), but was considered necessary to check the growth of bushes that sprung from the roots still living. The crop was small, as might have been expected from its preparation.

1828.—Corn, in rows five feet apart, and about three feet of distance along the rows, the seed being dropped by the step. Owing to unfavourable weather, and to insects and other vermin, not half of the first planting of this field lived; and so much replanting, of course, caused its product to be much less matured than usual on the weaker land. All the part not marled (and more particularly that matured) was so covered by sorrel as to require ten times as much labour in weeding as the marled parts, which, as in every other case, bore no sorrel. October 15th, gathered and measured the corn from the following spaces, which were laid off (by the chain), as nearly as could be, on the same land as in 1824.

The products so obtained, together with those of the previous and subsequent courses of tillage, will be presented below, in a tabular form, for the purpose of being more easily compared.

On the wheat succeeding this crop, clover seed was sown, but very thinly and irregularly. On the parts not marled only a few yards' width received seed, which the next year showed the expected result of scarcely any living clover. On the marled portions, the growth of clover was of middling quality; was not mowed or grazed, but seed gathered by hand both in 1830 and 1831.

1832.—Again in corn. It was soon evident that much injury was caused to the marled half, *q p o n*, by the too great quantity applied. A considerable portion of the stalks, during their growth, showed strongly the marks of disease from that cause, and some were rendered entirely barren. A few stalks

only had appeared hurt by the quantity of marl in 1828. On the lightly-marled piece, *w p*, and where the heaviest marling was accompanied by stable manure, there has appeared no sign of injury. The products were as follows :

Mark.	DESCRIPTION.	Products of Grain per Acre.					
		1st course. 1824. Oct. 11.		2d course. 1828. Oct. 15.		3d course. 1832. Oct. 26.	
		Bush.	Pecks.	Bush.	Pecks.	Bush.	Pecks.
s q	Not marled or manured	12		21	1	17	3½
q r 1	Marled at 800 bush.	19	3½	28	1½	28	
r p 2	The same	22	2	31	0½	27	3
r p 3	The same	27					
s t 5	Cowpen manure, 900 to 1100 bushels	22	2	25	2	bet. than s q	
s t 6	Stable manure, 900 to 1100 bushels	35	2	29		28	1
w t 7	Marl and stable manure, both as above	36		33	2	37	3½
w p	Marled at 450 bush. els	Less than r p (800)		Equal to r p		31	3

An accidental omission prevented the measurement of s t 5 in 1832.

This experiment has been made with much trouble, and every care bestowed to ensure accuracy. Still several causes have operated to affect the correctness of the results, and to prevent the comparative products showing the true rate of improvement either from marl or the putrescent manure. These causes will be briefly stated.

1st, The quantity of marl (800 bushels) on *q r* and *r p* is nearly double the amount that ought to have been used; and this error has not only increased the expense uselessly, but has served to prevent the increase of product that would otherwise have taken place. This loss is proved by the gradual increase, and, at last, the greater product of *w p* marled at only 450 bushels.

2d, The comparative superiority of all the marled ground to *s q* not marled, is lessened by this circumstance: most of the large logs, as well as all the small branches, were burned upon the land when it was cleared in 1824, before the experiment was commenced; and the ashes have durably improved a spot where each of these large fires were made on *s q*, but have done no good, and perhaps have been injurious to the marled pieces that were made sufficiently calcareous without the addition of ashes. At least, the good effect of ashes is very evident on *s q*, and has helped somewhat to increase all its measured products, and no such benefit has been visible on the marled parts.

3d, The quantity of putrescent manure applied to *s t* (900 to 1100 bushels) was much too great both for experiment and profit; and the quantity, together with the imperfectly rotted state of the stable manure, has given more durability to the effect than is to be expected from a more judicious and economical rate of manuring.

For these several reasons, it is evident that far more satisfactory results than even these would have been obtained, if only half as much of either marl or manure had been applied.

There are other circumstances to be considered, which, if not attended to, will cause the comparative increase or decrease of product in this experiment to be misunderstood. It is well known that poor land put under tillage immediately after being cleared, as this was in 1824, will not yield near as much as on the next succeeding course of crops. This increase, which depends merely on the effects of time, operates independently of other means for improvement that the land may possess; and its rate in this experiment may be fairly estimated by the increase on the piece *s q* from 1824 to 1828. The increase here, where time only acted, was from 12 to 21 1-4 bushels; but, as the corn gathered

here was always much the most imperfectly ripened, and would, therefore, lose the most by shrinking, I will suppose eight bushels to be the rate of increase from time, and that so much of the product of all the pieces should be attributed to that cause. Then, to estimate alone the increased or diminished effects of marl or manure on the other pieces, eight bushels should be deducted from all the different applications, the estimate will stand thus :

	1824.	1828.	Deduct for time.	Increase.	Decrease.	
	B. P.	B. P.	B.	B. P.	B. P.	
q r l	19 3½	28 1½	8	0 2	—	From 800 bushels of marl.
r p 2	22 2	24 1½	8	—	1 1½	From 800 bushels of marl.
r p 3	27					
s t 5	22 2	25	8	—	5 2	From 1000 bushels of cowpen manure.
s t 6	35 2	29	8	—	14 2	From 1000 bushels of stable manure.

Even the piece covered with both marl and stable manure (*w t*) shows, according to this estimate, a diminished effect equal to 10 1-2 bushels; which was owing to the marl not being able to combine with, and fix so great a quantity of manure in addition to, the vegetable matter left by its natural growth of wood. The piece *w p*, marled at 450 bushels alone, has shown a steady increase of product at each return of tillage, and thereby has given evidence of its being the only improvement made in such manner as both judgment and economy would have directed.—*Ruffin's Essay on Calcareous Manures.*

CHAPTER IX.

Lime and Gypsum.

Application of Lime.—Those purposes appear to be, first, to render whatever substances may be lodged in the soil, or matter which forms part of it, and which may be injurious to vegetation, either harmless or useful; and thus to prepare the soil for the reception and nourishment of seeds and plants: and, secondly, to facilitate the decomposition of putrescible matter, so as to furnish food to vegetables during their growth. It has been proved by careful experiment, that the application of lime is the only known alterative which, upon poor, weak, and weeping clays, has power to heal the soil. With the assistance of water, it suddenly decomposes all animal and vegetable bodies, and when thus spread upon neglected ground covered with heath and moss, the old turf is decomposed, and a saponaceous matter is formed which sinks into the soil, and covers it with sweet herbage. We also know that it imparts a certain degree of vigour to some peculiar plants, as for instance, sanfoin, the roots of which penetrate far into the interstices of chalk, and grow luxuriantly, though only covered by a slight coat of inferior soil.

It is, however, an error—though entertained by many farmers—to suppose that lime in any state comprises fertilizing properties within itself; and that, without operating upon the soil or upon the substances which it contains, it is an enriching manure. It does not possess any fertilizing principle in its own composition; it is merely a calcareous earth combined with fixed air, and holding a medium

between sand and clay, which, in some measure, remedies the deficiencies of both. But though, when alone, unfavourable to the growth of plants, yet experience shows that it is an ingredient in soils which, whether naturally forming a component part of their substance, so judiciously mixed with them by the husbandman, adds greatly to their fertility, for it has the power of attracting much both from the earth and from the air, which occasions the decomposition of plants; and thus converting them into nutriment, it gives power as to vegetation which, without its operation, would otherwise lie dormant. It also appears to act with great force upon that substance which, being already converted by the decomposition of plants into a species of earth, we call *mould*.

The other causes with which we are acquainted regarding the operation of lime as a manure would lead to a chymical discussion which could only prove uninteresting to the generality of our readers; we shall therefore confine ourselves to the following observations.

There can be no doubt that it is a powerful stimulant when applied to deep loams and heavy clays, which contain mould of a nature so sour as to appear to unfit them for the purposes of vegetation; or to land which has been previously either more or less manured with animal or vegetable substances, without any addition of lime or other calcareous matter, in which case it often produces effects far more fertilizing than the application of dung, for its active powers render every particle of the putrescent manure useful; but if the latter be not afterward repeated at no great distance of time, the soil will, in the course of a few years, become considerably exhausted. In all arable land, however impoverished it may be, either by nature or bad management, there yet always exists some portion of mould, and, on this, a first dressing of

lune occasions a sensible improvement of the soil, which soon becomes apparent in the increased product of the crops. A second dressing will also be attended with some apparently good effect; but unless that, and every succeeding repetition, be accompanied with ample additions of farmyard manure or other putrescent matter, to supply the loss thus occasioned by the exhaustion of the vegetative power. every future crop will be diminished. The land is then necessarily thrown out of cultivation, and left for a series of years to recover itself under pasture, which, in the course of time, may be effected according to its former condition; but, in the interim, it is rendered nearly fruitless. It is thus that many thousands of acres in every part of the kingdom have been run to a state of almost total infertility; and it is even said that the too great use of lime, though apparently judiciously employed by some of the first farmers in the Lothians, has been lately found very detrimental to their crops.

Marsh lands, however, which have been drained, will generally support a repeated and abundant application of lime, because they usually contain a large proportion of matter upon which the stimulating powers of lime are peculiarly adapted to act; and it will be found much better suited to the purpose than dung. On all rich, deep, dry, and loamy soils, it may also be applied with effect; for although they contain within themselves the component parts of the best soils, yet they are frequently found to be sluggish and inert; and dung, whether through imperfect fermentation, or owing to the want of calcareous matter, often remains dormant in the land until roused by moderate quantities of quicklime, which, if applied at distant periods, will effectually operate to bring it into activity. It should, however, be turned into the ground some weeks before the dung, in order that it may become thoroughly slacked by mixture with the soil, or otherwise

it would have the effect of abstracting some of its nutriment. Such soils, after the application of lime, produce much heavier crops with a much smaller proportion of dung than if no lime had been used, because the operation of the latter acting upon the dung renders every portion of it useful.

Clay land shows an evident disposition to combine with lime, and it bears the repetition of this species of amelioration better than lighter soils. When applied to heavy tillage-land, either for the purpose of reducing its cohesive properties or of supplying an additional quantity of calcareous matter, small dressings of lime will have but little effect; and if sand or calcareous earths are to be employed, it is recommended, by a practical farmer of known experience, as more economical to apply them separately than as a compost. It powerfully assists all adhesive soils; and when laid hot from the kiln upon deep clay, it has been known to occasion a very large increase in the following crops. It has also been often observed in fallowing clayey soils, "that, in wet weather, when a dose of lime has been just given, the land continues more friable, and is less apt to bind up on the recurrence of drought, than where it has been neglected. The grain growing on the well-limed ground preserves its healthy appearance in wet seasons, while that growing on land that has not been limed is yellow and sickly."

Upon *sandy soils*, which seldom abound much in vegetable matter, lime has a mechanical operation, which, by combining with the finer particles of the soil, gives consistence to the staple of the land, and attracting the moisture from the atmosphere, it imparts it so gradually as to be less liable to be hurt by drought in those parching seasons by which crops are injured. It is therefore said to be cooling to hot land; but if it be not also mixed with some portion of clay, with which it may combine, it then is

apt to unite itself with the sand, with which it composes a kind of mortar, the effect of which has been already described, and which cannot be dissolved without much difficulty, and the plough often brings hard lumps to the surface of the soil which cannot be easily broken. Thus, when such land has been frequently limed, nothing can restore it but the abundant and reiterated application of putrescent manure; the demonstration of which is perceptible throughout many parts of England, where, from possessing a chalky soil without strength to maintain a sufficiency of livestock to furnish dung, the land has in many places been worn out through the inconsiderate use of lime.

On the *exhaustion of land by the application of lime*, there is, however, much difference of opinion. It is indeed evident that the continuation of cropping, without an addition of nutritive manure, will ultimately exhaust the best soils; but though their natural fertility be thus aided, it yet cannot depend entirely on that support. This must be apparent if we reflect that land, without any addition of animal or vegetable substance, will still produce crops; for pure sand, clay, and chalk, though each in themselves separately barren, yet, when mixed together, exert chymical influences upon each other, which, by the attraction of the air, the dews, and the rain, the force of the sun, and the generative powers of growing vegetables, effect the production of corn and fruit. It is therefore clear that the land alone is capable of vegetation; but every day's experience proves that the amount of its products, its fertility, in short, depends in a great degree upon the decomposition of the substances which have been previously converted into vegetable mould, or which are added to it by manure. Anything whatever may be called manure which, when applied to the soil, either rectifies its mechanical defects, corrects any bad quality, and either stimulates it to yield

or stores it with nutriment. Thus, if lime be laid upon pure sand, although the latter would be rendered more tenacious, and would thereby become more favourable to the germination of vegetables, yet seeds could find no nourishment from either the lime or the sand, and putrescent manure would still be necessary to produce a crop. But if the soil consists of clay and sand, containing animal or vegetable matter in a torpid state of decay, then lime would be preferable to dung. The state of the soil should therefore be minutely inquired into before lime is employed, and it should be only used to give effect to the inert substances with which it may be combined.

By the analysis of soils, we find that all productive earth contains a certain portion of lime ; and although we learn from experience that its stimulative powers upon the roots of plants are very great, yet we are but imperfectly acquainted with the extent or the exact manner in which its influence is brought into action, and "we are in a great measure ignorant of the actual changes that are produced upon the earth after this manure has been applied." It would, however, seem that, where it exhausts, it is only by hastening the putrefaction of the animal and vegetable matter in the soil, and by that means applying a larger portion of those substances in a given time than could be otherwise afforded to the growth of plants. It is thus known to produce more luxuriant crops, and it will also, consequently, enable the farmer to continue his land in tillage during a certain time, with more effect than if no calcareous manure had been laid on ; but, although it may not tend to the deterioration of the original staple of the soil, it can hardly be doubted that it must be thus more promptly deprived of its fertility than if the exhaustion of that vegetable mould with which it had been supplied by nutritive manure were occasioned by a more gradual process of decomposition.

That this is the only way in which effete lime can exhaust land, seems probable from the large quantities of neutralized calcareous earth which are often applied without any bad effects in the form of chalk, shells, limestone, gravel, and the whole tribe of marls. A larger quantity of these is oftener laid on in one year than would be used of lime in half a century, were the land in tillage to be managed according to the custom of some countries; yet it is not generally impoverished, and, in many cases, it is permanently improved. This, however, is probably occasioned by its combination with other substances, which either counteract its exhausting powers, or supply the waste of nutritive matter.

The employment of lime seems to be of the greatest service in the *breaking up of fresh and coarse land*, on which it acts more powerfully than on soil which has been long in cultivation, and, indeed, the most striking improvements have been effected by its means on moorlands and mountain; but it should be given for the first time abundantly. Such is the usual effect of lime upon arable; upon *grass-land* it is laid in smaller quantities; and in this top-dressing, perhaps the preferable mode is to apply it in a compost with earth, except when the soil consists of clay. When thus spread upon the surface, its action upon the sward is productive of the most palpable improvement, and continues perceptible during a long period. No other manure will create so rapid a change; for it is such an excellent corrector of acidity, that it tends to produce the sweetest herbage where only the most unpalatable pasture was formerly to be found. This, indeed, is so apparent, that if a handful of lime be thrown upon a tuft of rank, sour grass, which has in former years been invariably refused by cattle, they will afterward eat it close down. Now, animal dung, when dropped upon coarse bent sward, produces little or no improvement until limed; it then, however,

not only augments the crops, but the finer grasses continue in possession of the soil, and the land is then doubly benefited; for the dung dropped by the stock on which it is pastured is both increased in quantity and improved in quality.* Farmers should never consider lime as the food or nourishment of plants, but as an alterative of the soil; never to be used but when nature requires it, either to dissolve noxious combinations, or to form new ones; to bind loose soils, or to diminish excessive cohesion; and to reduce the inactive vegetable fibre into a fertile mould. For such purposes there is not, perhaps, a more valuable article in the whole catalogue of agricultural remedies; but some farmers, who do not reflect upon the subject, when they perceive that lime has once excited the dormant powers of the soil into action, and that very good crops succeed for a few years, are apt to draw from thence very false conclusions, and continue liming and tilling without the assistance of putrescent manure, until their land at length is rendered incapable of the production of corn. It has indeed been pertinently observed by a good judge of such matters, "that there is an analogy between the treatment suitable to the animal and vegetable creation. When medicines have removed the cause of their application, they are discontinued, and the patient, rendered weaker by the application, requires some invigorating aliment; in like manner, some time after an effectual liming, the soluble carbon of the rotten dung, or some such restorative, should be applied to the soil to replenish it with what it may have been robbed of by the action of the lime."

* In Derbyshire the farmers have found that, by spreading lime in considerable quantities upon the surface of their healthy moors, after a few times the heath disappears, and the whole surface becomes covered with a fine pile of grass, consisting of white clover and the other valuable sorts of pasture-grasses.—Anderson's Essays, 4th edit., vol. i., p. 527. Survey of Derby, vol. ii., p. 437; and of Westmoreland, p. 235.

In fine, lime should always precede putrescent manures when breaking up old leys for cultivation; for, if the land contains acids or noxious matter that is poisonous to plants, they will be decomposed and rendered fit for vegetation; and hence the superiority of lime to dung on new lands. But calcareous and putrescent manures operate very differently: "the former, being more stimulant and corrective, help the farmer to an abundant crop at the expense of the soil alone; while the latter furnish the land at once with fertilizing fluids, and will ensure a good crop on a place perfectly barren before and after the application of lime."

Much uncertainty prevails among farmers *regarding the state of lime*; some contending that it should only be applied when hot and powdered, and that, when it has been slacked, its effect is comparatively trifling; others maintain the contrary. But these disputants consist chiefly of men whose experience has either been confined to one kind of soil, or who have only used it under particular circumstances; and as they only condemn the system of others because their own has turned out successful, or the reverse, it is not improbable that, in the view they take of the subject, each may be in the right. It will therefore probably be found, that in all cases where the land is constitutionally disposed to receive benefit from a calcareous dressing, that is to say, when it has not been previously limed, or when it has been long laid down and refreshed by grass, or enriched by the application of dung, it is of little importance whether the operation take place when the lime is quick or effete. Upon waste lands, however, its causticity has an evident and necessary effect; for the undecayed vegetables, which abound in all soils in a state of nature, should be speedily decomposed, and it should therefore be spread hot from the kiln. In point of economy, too, there can be no doubt but that it is most thriftily used when

laid upon the land in the latter state: for the labour is less, and a smaller quantity will serve the immediate purpose. It is, however, obvious that the choice of circumstances and season is not always in the farmer's power; and that necessity often obliges him to lay it on when completely effete. It has been said, indeed, upon high authority, that caustic lime exhausts the land; but repeated trials have shown that its ultimate effects are equally beneficial in the one state or the other, though there is a more immediate advantage in the employment of quicklime by the destruction of weeds. A common method is to leave it spread during some months upon clover or sainfoin, not intended to be broken up until the following year; a plan which is advisable with regard to marl, which partakes of some of the qualities of lime, and is the better if allowed to remain during a season exposed to the atmosphere; but the stimulating properties of quicklime will be thereby lost, as it will be converted into mere chalk. Opinions are also much divided respecting the effects when laid upon pasture-land which is intended to be kept in grass. There is, indeed, no question that, in either state, if applied in moderate quantities to a dry soil, or to land that has been completely drained, such a top-dressing will have the most beneficial effect upon the herbage; but it must be admitted, that, when laid on quick, it requires more circumspection in its application, and should not be employed in the same quantity as when effete.—*British Husbandry.*

Gypsum.—Besides being used in the forms of lime and carbonate of lime, calcareous matter is applied for the purposes of agriculture in other combinations. One of these bodies is gypsum or sulphate of lime. This substance consists of sulphuric acid, the same body that exists, combined with water, in oil of vitriol, and lime, and; when dry, is composed of 55 parts of lime and 75 parts of sulphuric acid.

Common gypsum or selenite, such as that found at Shotoverhill, near Oxford, contains, besides sulphuric acid and lime, a considerable quantity of water, and its composition may be thus expressed : sulphuric acid, one proportion, 75 ; lime, one proportion, 55 ; water, two proportions, 34.

The nature of gypsum is easily demonstrated : if oil of vitriol be added to quicklime, there is a violent heat produced ; when the mixture is ignited, water is given off, and gypsum alone is the result, if the acid has been used in sufficient quantity ; and gypsum mixed with quicklime, if the quantity has been deficient. Gypsum, free from water, is sometimes found in nature, when it is called anhydrous selenite. It is distinguished from common gypsum by giving off no water when heated. When gypsum, free from water, or deprived of water by heat, is made into a paste with water, it rapidly sets by combining with that fluid. Plaster of Paris is powdered, dry gypsum ; and its property as a cement, and its use in making casts, depends on its solidifying a certain quantity of water, and making with it a coherent mass. Gypsum is soluble in about 500 times its weight in cold water, and is more soluble in hot water ; so that, when water has been boiled in contact with gypsum, crystals of this substance are deposited as the water cools. Gypsum is easily distinguished by its properties of affording precipitates to solutions of oxalates and barytic salts. It has been much used in America, where it was first introduced by Franklin on his return from Paris, who had been much struck with its effects there. He sowed the words, *this has been sowed with gypsum*, on a field of lucern, near Washington ; the effects astonished every passenger, and the use of the manure quickly became general and signally efficacious. It has been advantageously used in Kent, but in most counties of England it has failed, though tried in various ways and upon different crops.

Very discordant notions have been formed as to the mode of operation of gypsum.—It has been supposed by some persons to act by its power of attracting moisture from the air; but this agency must be comparatively insignificant. When combined with water, it retains that fluid too powerfully to yield it to the roots of the plant, and its adhesive attraction for moisture is inconsiderable; the small quantity in which it is used, likewise, is a circumstance hostile to this idea. It has been erroneously said that gypsum assists the putrefaction of animal substances and the decomposition of manure.

The ashes of sainfoin, clover, and rye-grass, afford considerable quantities of gypsum, and the substance is intimately combined as a necessary part of their woody fibre. If this be allowed, it is easy to explain the reason why it operates in such small quantities; for the whole of a clover crop or sainfoin crop on an acre, according to estimation, would afford by incineration only three or four bushels of gypsum. The reason why gypsum is not generally efficacious, is probably because most cultivated soils contain in it sufficient quantities for the use of the grasses. In the common course of cultivation, gypsum is furnished in the manure, for it is contained in stable dung, and in the dung of all cattle fed on grass, and it is not taken up in corn-crops, or crops of pease and beans, and in very small quantities in turnip-crops; but where lands are exclusively devoted to pasturage and hay, it will be continually consumed. Should these statements be confirmed by future inquiries, a practical inference of some value may be derived from them. It is possible that lands that have ceased to bear good crops of clover or artificial grasses may be restored by being manured with gypsum.

CHAPTER X.

Animal and Vegetable Manures.

ALL substances which, when mixed with the matter of the soil tend to fertilize it, are, in common language, termed manures.

Manures may be composed of animal or vegetable substances; or they may consist of mineral matter; or they may be partly derived from mineral and partly from animal and vegetable substances. They may therefore be classed, according to their origin, into

1. Animal and vegetable manures.
2. Mineral manures.
3. Mixed manures.

In describing this class of substances, it is not my design to treat of their chymical mode of action. This investigation forms one of the most interesting parts of the chymistry of agriculture: but it is not essential to that practical knowledge of the subject which will suffice for the common purposes of the farmer. The remarks to be made, therefore, on the mode of action of these bodies, will be of a very general nature.

1st. *Animal and Vegetable Manures.*—Chymical analysis shows us, that all plants and all the products of plants are resolvable into a small number of simple bodies, in various states of combination. These bodies are, carbon, hydrogen, oxygen, and, in smaller quantity, nitrogen or azote. These form the essential constituents of all vegetable substances. But there are likewise formed in plants, though in comparatively minute quantity, certain other bodies, consisting chiefly of the four earths,

silica, alumine, lime, and magnesia, of the oxyde of iron, and of the alkalies, soda and potassa, but chiefly the alkali potassa.

Now all these bodies, or the elements of all these bodies, exist in animal and vegetable manures ; for these, being animal and vegetable substances, are resolvable into carbon, hydrogen, oxygen, and nitrogen, with the intermixed earthy and other bodies existing in the living plants.

In supplying, therefore, animal and vegetable substances to the soil in a decomposing state, we, in truth, supply the same substances which enter into the composition of the living plants. The substances, indeed, exist in the dead matter of the manures, in states of combination different from those in which they exist in the living vegetable : but still they are present, and must be believed to supply the matter of nutrition which the plants in growing require. Science has made known to us the truth, that the living plants and the dead manures are resolvable into the same elementary substances ; but experience has not the less taught the husbandman in every age, that all animal and vegetable substances, mixed with the matter of the soil, tended to fertilize it, by affording nourishment to the plants which it produced.

The simple bodies which form the substance of manures exist in various states of combination, and often in the solid state. Now there is reason to believe that, in order that these solid matters may be absorbed by the roots of the growing plants, they must be dissolved in water. The absorbing pores of the roots of plants are so minute, that they are only to be discovered by the microscope. The solid bodies, therefore, which find their way into these pores, may reasonably be supposed to be held in solution by that aqueous matter which enters into the roots of plants, and forms the sap. Water is apparently the medium by which all the matter

of nutrition, in whatever form, is conveyed into the roots of plants, and without which, accordingly, vegetation is never known to take place.

Holding this opinion to be just, the substances which form vegetable and animal manures, before they can be rendered available as nutriment to plants, must be rendered soluble in water.

Of the means which nature employs for this purpose, fermentation appears to be the chief. By this process, the elementary parts of the substance fermented assume new forms of combination, and become fitted to supply the matter of nutrition to plants, in that form in which it can be received, by the pores of the roots. The fermentative process is completed after the substance to be used as a manure is mixed with the matter of the soil; but it is common also to cause it to undergo a certain degree of fermentation before it is mixed with the earth. This is the method of preparing this class of manures for use, which is employed in the practice of the farmer.

Animal matters decompose with facility when acted upon by moisture and the air, the greater proportion of their elementary parts making their escape in various forms of gaseous combination, and leaving the earths, alkalies, and carbonaceous matter remaining.

When this decomposition takes place beneath the surface of the ground, these gaseous compounds, as well as the carbon (which there is reason to believe assumes also the gaseous state by combining with oxygen), may be supposed to be partially or wholly retained in the earth, to afford the matter of nutrition to the plants.

Purely animal substances, therefore, which thus readily decompose, do not absolutely require fermentation before they are mixed with the soil. Yet even in the case of purely animal substances, certain beneficial consequences result from subjecting

them to a previous state of fermentation. Thus the urine of animals, when applied in its recent state to the soil, is not found to act so beneficially as a manure as when a certain degree of previous fermentation has been produced.

And there is another purpose promoted by causing even pure animal matter to undergo fermentation, and this is, that, being mixed with vegetable matter, it promotes the more speedy decomposition of vegetable fibre.

Vegetable fibre is, under certain circumstances, a slowly decomposing substance. When vegetables are green and full of juices, they readily ferment; but when the stems are dried, as in the case of straw and other litter, they decompose with slowness, and the mixing them with animal matter hastens the putrefactive fermentation. This mixing of animal with vegetable matter is the process employed for preparing the greater part of the dung of the farm-yard.

The dung of the farmyard is the produce of the hay, straw, turnips, and other substances used as forage or litter upon the farm. It is collected into one or more yards, and fresh litter and all other refuse being added to the mass, it gradually accumulates, until it is carried out to the fields for use.

The manner of feeding cattle in their houses and yards will be afterward explained. It is sufficient, with relation to the present subject, to observe, that the larger cattle may either be fed in stalls in close houses, or in yards in which they receive their food. When they are fed in close houses, their dung and soiled litter are carried to the heap in the yard, where it gradually accumulates; and when they are fed in the yards, then dung, in like manner, accumulates there, being, in the mean time, compressed by their treading upon it.

In the practice of the farm, to be afterward especially described as suited to the circumstances of

this country, the larger cattle of different kinds are brought home to their houses and respective yards before winter. Some are kept in their stalls in close houses, and their dung and soiled litter are carried out daily to the yards, while others receive their food in the yards themselves, and thus tread upon the heap. In this manner the mass of dung accumulates during the period of feeding, and at the proper period, in the following spring or summer, is carried out to the fields and applied to the land.

The dung of the farmyard is thus sure to be a collection of animal and vegetable substances. It consists of the excrements of the animals kept and fed upon the farm, together with the straw or other materials used as litter, and generally of the refuse and offal produced about the homestead. This mixed mass is collected during the period of feeding, when it undergoes a certain degree of fermentation. When trodden by the feet of the animals kept in the yards, the effect is to exclude the external air, and to prevent the fermentative process from proceeding with that rapidity which would take place were the mass not compressed.

The principal animal substances which are mixed with the ligneous fibres of the litter, and which cause it to undergo decomposition, are the dung and urine of the animals.

The properties of this dung, to a certain extent, depend upon the kind of animals and the nature of their food. The dung of horses is easily fermented, and is more readily decomposable in proportion to the succulence and nutritive qualities of the food consumed. This also holds with respect to the dung of oxen. When the animals are fed on straw and the dried stems of plants, the dung is less rich and decomposable than when they are fed on turnips, oil cake, and other nourishing food : and the same thing holds with respect to the dung of the hog and

other animals. The dung of the different feeding animals is mixed in greater or less proportion with their litter, and the greater the proportion of the animal to the vegetable matter, the more readily will it ferment and decompose.

The urine of the animals, again, is in itself a very rich manure, and contains, in certain states of combinations, all the elements which enter into the composition of plants. It is necessarily mixed with and partly absorbed by the litter and other substances in the yards, of which it hastens, in a material degree, the fermentation.

The urine, however, is apt either to make its escape by flowing out of the yards, or to be imperfectly mingled with the litter. It becomes, therefore, a part of the management of the farmyard to provide against either of these contingencies.

The farmyard should be made level at the bottom, and paved, if the subsoil be loose and sandy, and the bottom should be sunk somewhat below the surface of the ground. As a portion of the liquid will flow from the stables and feeding-houses, gutters of stone should be made to convey the liquid from these into tanks or other reservoirs adjacent to the yards. The same means are to be taken for conveying away any excess of liquid from the yards themselves. This is not done for the purpose of draining the yards of moisture, which would be an error, but for the purpose of preventing any excess of liquid from being lost. The principal cause which produces a great flow of liquid from the yards is an excess of rain, which, falling upon the heap faster than it can be absorbed, washes away the urine.

Three methods may be adopted for the management of the liquid which is obtained from the feeding-houses, or which oozes or is washed off from the mass in the yards.

1. It may be pumped from the tank or reservoir

into which it had flowed, conveyed back to the farm-yard, and spread over the surface of the heap. In this manner it will be imbibed by the litter, and tend to hasten the decomposition of the mass.

2. It may be pumped up when convenient, and conveyed in barrels to the field, and spread over the surface, a species of manuring which, under certain circumstances, is exceedingly efficacious.

3. In the bottom of the tank or reservoir to which the liquid is conveyed, may be placed absorbent earths, stems of plants, and other matters. These being saturated, will become very rich manure, and may either be carried from the tank to the field, and applied to the ground, or put into heaps or composts, until the period of using them shall arrive.

This method of collecting the excess of the liquid from feeding-houses and yards is perhaps the best in the common practice of the farms in this country. In Flanders, where extreme care is bestowed in the collection and preparation of liquid manures, there is a smaller proportion of straw and hay produced on farms than in the mixed system of agriculture of Britain. There is not, therefore, so great a proportion of ligneous fibre to be decomposed. The Flemings, accordingly, pursue the mode of managing their manure which the circumstances peculiar to their agriculture render expedient. They can always ferment sufficiently the fibrous matter of the heap of their farmyards, and therefore they have always a spare supply of liquid in a separate state. But in this country, where we aim at producing a large quantity of hay and cereal grasses, we require nearly all the liquid from the feeding animals to moisten and ferment the general mass of the farmyard.

When the animals of the farm are fed on tolerably rich and succulent food, and when the proportion of straw is not too large, there is no difficulty in fermenting the mass of the farmyard to the de-

gree required; but, when the quantity of straw is very large in proportion to the more moist and succulent food consumed, as sometimes occurs in the case of clay land farms in certain districts, then there may be considerable difficulty in getting the straw sufficiently fermented and decomposed for use. This may arise from want of moisture as well as from a deficiency of animal matter; and as we may not at the time have the power of supplying the latter, we must endeavour to keep the heap moist by soaking it, in the absence of rain, with water. But the permanent remedy for this evil is to increase the quantity of such nourishing food as the farm will produce, namely, cabbages, tares, clovers, and other succulent and nutritive plants.

Sometimes, even when there is no extraordinary excess of dry litter, the fermentation of the heap in the yard, after proceeding to a certain degree, suddenly stops, by which the manure is much injured. This action is termed *fire-fanging*. It arises from the want of moisture, and, when it happens, it is often very difficult to renew the fermentation. The best remedy is to turn over the heap, soak it with water, and mix it with horsedung or any animal offal that can be obtained.

With these exceptions, the management of the farmyard is not attended with any difficulty. We have seen that the mass consists of a collection of the excrements of the animals kept upon the farm, of the straw and other substances employed for litter, and, generally, of any refuse or offal produced at the homestead; and that this mixed substance is accumulated chiefly during the months of winter, undergoing during this period a certain degree of fermentation and decomposition in the yard where it lies.

The substance thus collected and partially fermented, is to be applied to the grounds during the months of spring, summer, or autumn, immediately

following the winter in which it has been prepared. It should be always applied as soon after it is prepared as possible, there being a waste either in retaining it too long, or in causing it to undergo a greater degree of fermentation than is required.

In the process of the putrefactive fermentation, the elements of the body fermented, in assuming their new forms of combination, partly make their escape in the gaseous state. In the fermentation of manures, the decomposition may proceed so far that the great mass of the substance shall be exhaled, leaving behind only the earthy and alkaline, and a portion of the carbonaceous matter of which it is composed. In the treatment of this class of substances, therefore, the putrefactive fermentation should neither be continued longer, nor carried to a greater degree than is necessary for the purposes intended.

In practice, our object is to produce certain kinds of crops; and certain kinds of plants, it is found, require a greater action of manures at particular stages of their growth than others. Thus the turnip, the carrot, and the beet, which are sown, as will afterward be seen, in the early part of summer, require that the manure applied shall be in such a state of decomposition as to act upon and nourish them in the first stages of their growth; and if this be not so, the crop may entirely fail. In these and similar cases, accordingly, a complete preparation of the farmyard dung is an essential point of practice.

Certain plants, again, do not require the same state of decomposition of the dung. Thus the potato requires less in the first stages of its growth than the turnip, and hence it is not necessary to subject the manure to be applied to the same degree of fermentation. The same remark applies to Indian corn.

In some cases, too, as in the process of the sum-

mer fallow, to be afterward described, the manure is mixed with the soil some time before the seeds of the plants to be cultivated are sown. In such case, the manure undergoes the necessary fermentation in the soil itself, and does not require that previous preparation which, in the case of the turnip and some plants, is required.

But where no necessity exists for fermenting the matter of the farmyard beyond the degree requisite for the special purpose intended, it is always a point of good practice to ferment it to that degree. In order to know when dung is sufficiently fermented for the particular use required, a very little practice and observation will suffice. When it is fully fermented, the long stems of straw which formerly matted it together are in such a state of decomposition that the parts can be readily separated by a fork. It is not necessary, in any case, that it be in that extreme state of decay in which we often see it used by gardeners, and when it can be cut with a spade like soft earth. Whenever farmyard dung has been fermented to this degree, it has been kept beyond the proper time, and the management has been bad.

The mass, we have seen, is collected chiefly during the months of winter, and will always be ready to be applied to the ground in the spring, summer, or autumn immediately ensuing; and there is no case in which it is advisable to keep it beyond the year in which it has been collected.

The common and convenient practice is to carry it out from the yards where it has been collected to the field where it is to be used, and there to pile it up in one or more large heaps, so that it may undergo the further decomposition required before being applied to the land.

The dung, as it is carried out to the fields, is to be laid in the large heaps, which may be about four and a half feet high, and of such other dimensions

as may be convenient. When the dung is placed in these heaps, it is in a state very favourable to farther fermentation; for it is to be observed that, in all cases, the turning over the dung, so as to give access to the air, causes an increase of fermentation, and this is the method adopted by farmers and gardeners when they want to give a greater degree of fermentation to any heap. Should the dung in these large heaps not ferment to the degree required, they are to be turned over and formed into new heaps, the upper part being placed below, and what was before below at the top. By this means the fermentative process will be renewed; and, should this turning not be found sufficient, the heaps must be again turned over, so that they may be brought to the degree of decomposition required. The large heaps of this kind should not be placed in a very exposed situation, so as to be too much acted upon by the winds, and it is often a good precaution, and a necessary one in very warm countries, to face up the sides with a little earth or turf, and to strew some earth upon the top, so as to prevent the escape of decomposing matter. When it is wished to hasten the putrefactive process in these heaps, it is better that they be not compressed by the carriages going upon them to unload; but, where there is no peculiar necessity for hastening the putrefactive process, the carriages and beasts of draught can go upon the heap without injury. When peculiar care is required, as when the dung has been injured by fire-fanging, or otherwise imperfectly fermented in the yards, it should be spread over the heap in layers, so that one layer may undergo a slight fermentation before it is compressed by that which is to be placed above it.

Sometimes the mass may be turned over in the yards where it lies, and allowed to ferment, before it is carried out to the fields for use. In this case the workmen begin at one side of the heap, and

with large forks turn it over, laying that which was before uppermost underneath, so as that the whole may be reversed. If, after this process of turning, no treading of cattle is allowed, the fermentation of the mass will proceed with rapidity, and then the whole may be led out at once from the yards to the fields for use.

When the dung produced is very rich and well decomposed, as when cattle have been feeding in stalls on juicy and nutritive food, it may not appear to require this turning over to fit it for use; yet, even in such a case, it is generally beneficial that it be turned over at least once before being used, the effect being to ferment the mass not only sufficiently, but equally, and to mix its different parts together. It may be observed, also, that when the mass of vegetable and animal substances is thrown into a common yard, some care should be bestowed in spreading it equally, so that one part of the yard may not be filled with rich dung and another with poor. The dung of horses, for example, is more susceptible of quick fermentation than that of oxen. When the stable, therefore, opens upon a common yard, the horsedung should not be suffered to accumulate in a mass about the stable door, but spread abroad upon the heap.

Farmyard dung is chiefly applied to the soil by being spread upon the land when in tillage, and covered by the plough. The periods at which this is done, and the manner of doing it, will be afterward pointed out. By being covered by the earth, the dung soon passes through its course of fermentation, and becomes decomposed and mixed with the matter of the soil.

This valuable substance must be economized in the manner of applying it. The soil must be kept as rich as the means at the farmer's hands will allow; but it is an error in practice to saturate it at one time with manures, and to withhold them at

another. They ought rather to be applied in limited quantity, and frequently, so as to maintain a uniform or increasing fertility in the soil.

The produce of the farmyard will necessarily afford the chief part of the manure consumed upon farms which do not possess extraneous sources of supply. But besides the produce of the farmyard, there are certain vegetable and animal substances which, in their separate states, may be applied to the manuring of land. An example of the application of vegetable substances in this state is where certain plants are allowed to come in flower, and are then ploughed down in their green state, and mixed with the matter of the soil. This is a practice derived from very ancient times, and is yet followed in Italy and other parts of Europe.

Vegetable matter, when thus covered by the soil in its green and succulent state, readily undergoes decomposition, and forms a very enriching substance. The practice, however, is chiefly suited to the warmer countries, where vegetation is very rapid, and even then it argues a somewhat low state of the art, and is not the best way for producing decomposing matter for manures. When we are able to raise green food of any kind, it is better that we apply it in the first place to the feeding of animals, for then it not only yields manure, but performs another and not less important purpose.

When, however, the practice is for any reason adopted, the period at which the plants should be ploughed down is just when they are coming in flower, for then they contain the largest quantity of readily soluble matter, and have the least exhausted the nutritive substance of the soil. The plants employed for this purpose by the ancients were chiefly the leguminous, as the Lupine, which is still used in Italy for the same purpose. Buckwheat is also employed, and appears to be the plant best suited for the practice in northern countries, for it is easily

cultivated, and soon arrives at the necessary maturity. For the same reason, Spurry has also been cultivated for this purpose; nay, the clovers have been thus employed, at the suggestion of speculative writers, even in England, and thus the error has been committed of employing a valuable article as a manure, which might have been employed, in the first place, in supporting the livestock of the farm.

The leaves of trees also form a vegetable manure, though not a good one; for, although leaves enrich to a certain degree the surface upon which they fall and decay, they will rarely pay the expense of collecting them expressly for manuring land.

The roots of plants, disengaged from the soil in the process of tilling and cleaning it, are also employed as a vegetable manure. Some of these, however, as the couch grass, being very vivacious, would readily spring again: and therefore it is necessary that their vegetative powers be destroyed, which may be done by mixing them with lime, and forming in this way a compost. Many farmers, however, to save time, or to prevent the risk of the plants springing again, burn them in little heaps upon the ground at the time of their being collected, and spread the ashes upon the surface. This may be sometimes convenient, but the effect is, that the principal nutritive part of the plant is dissipated, and nothing left but the carbonaceous, earthy, and other insoluble matter.—*Low's Elements of Practical Agriculture.*

CHAPTER XI.

The Atmosphere.

A knowledge of its elements and offices important to the Farmer.—A knowledge of the constituents of the atmosphere, and of the various and important offices which it performs in animal and vegetable economy, is valuable to the farmer, not only as serving to aid him in all his rural, money-making operations, but as offering a source of high intellectual enjoyment. Although the subject may be deemed too abstruse for our humble columns, we consider it fraught with so much useful instruction, that we doubt not it will be read with interest by hundreds of our young patrons; and we would fain hope that it may lead some of them into a course of study in physical science which will not only benefit them individually, but ultimately become beneficial to man. The Creator has endowed us with power to become acquainted with many of the wonderful phenomena of nature, and of rendering them subservient to our wants; and in this country, the humblest individual is furnished with leisure and ample means to pursue the inquiry. The time and means that are usually devoted, in early life, to frivolous and often deleterious pleasures, would suffice to lay in a stock of useful knowledge which would become a blessing and a treasure in after life. But it should never be forgotten, that in all our undertakings, application and perseverance are the only sure means of success. With these views and hopes we shall briefly describe the principal constituent parts of the atmosphere and some of its more important offices, that seem most likely to interest the agriculturist.

The atmosphere is composed principally of two invisible gases, termed *oxygen* (sometimes vital air) and *azote* or *nitrogen*, in the proportion of about four fifths of the latter and one fifth of the former. This proportion is found to exist, with trifling modifications, in all latitudes and at all elevations. Although these elements are invisible in the atmosphere, they both assume liquid and solid forms under many and various circumstances.

Nitrogen abounds in animals, but seldom to a great extent in plants. It is, however, found in wheat, in what is termed the gluten, and it is this which gives to that grain its prominent value. "It is the base of ammonia and nitric acid (*aqua fortis*), and appears to be the substance which nature employs in converting vegetable into animal substances."—*Fourcroy*. Its principal office seems to be, to neutralize, in some measure, the properties of oxygen, and to render it fit for respiration and combustion.

Oxygen enters more or less into animal and vegetable matters; it constitutes 88 parts in 100 of water, forms from 40 to 70 per cent. of all vegetable acids, more than 40 per cent. of the wood of the oak and beech, about 50 per cent. in starch, the principal nutritious property afforded by grain, pulse, and roots, and 64 per cent. in sugar. It is essential in animal and vegetable life; it is necessary to fermentation, to combustion, to the germination of seeds, and the development and maturity of plants; and, combining with the carbon of the blood, it produces the greatest portion of animal heat. It also combines with metals and forms oxydes, or, in common language, *rust*.

Nitrogen and oxygen are called simple bodies, because they are incapable of division or decomposition.

Carbonic acid gas, also, is found to constitute about one thousandth part of the atmosphere, and in win-

ter it has been found to amount to one five hundreth part. This is a compound substance, composed of two parts of oxygen and one of carbon, the latter being found pure in the diamond, and forming the substance of mineral and wood coals. This gas is produced in abundance by fermentation, respiration, and combustion; is absorbed and decomposed by the leaves of plants, which retain the carbon and give off the oxygen, and constitutes a large portion of the woody matter of plants. The causes which produce it, sometimes, in confined situations, give it in such excess as to render it prejudicial to animals; but the free access of atmospheric air soon restores the equilibrium. It constitutes the proper food of plants. Thus animals and vegetables are mutually benefited, through the wise provisions of the Creator, by their proximity to each other; plants giving off oxygen necessary to animals, and animals giving off carbonic acid gas, the pabulum of vegetable life.

Water also exists in the atmosphere in the form of an elastic fluid. This fluid is found to form, at the temperature of 50° Fahrenheit, about one fiftieth of the volume of the atmosphere, in the driest time in summer, and is increased with the increase of temperature, heat accelerating evaporation from the earth's surface. When the temperature of the air is diminished, the aqueous fluid is condensed, and appears in the atmosphere in the form of vapour or clouds, and is copiously deposited, in summer in the form of dew. This water is retained principally in the lower regions of the atmosphere. It is so slightly united with the other elements of the atmosphere, that a change of temperature produces a change in its proportions: while nitrogen, oxygen, and carbonic acid preserve always nearly the same relative proportions.

"Independently of those bodies which essentially constitute the atmosphere," says Chaptal, "there

are mingled in it the exhalations constantly arising from the earth; these are again disengaged from the air, and precipitated, as soon as the heat or any other cause which occasioned their ascension ceases to act upon them. These exhalations modify the properties of the air [by the carbonic acid, &c., disengaged from animal and vegetable matters in a state of putrefaction] and affect its purity. The oxygen and the water of the atmosphere become impregnated with the particles of the exhalations which are deposited with them upon the surfaces of other bodies, where they remain in contact, or enter into combination, with them. The origin and dissemination of many maladies may be traced to this source; the germe of them is carried through the air by the aqueous fluid. And for the same reason it is that intermittent fevers are endemic in those situations where large quantities of animal and vegetable matter are under decomposition, as upon the borders of ponds and marshes; and that the miasm, which arises from numerous animal remains in a state of decomposition, become a fruitful source of disease. It is, for the same reason, also, dangerous under some circumstances to breathe the evening air; the aqueous fluid contained in it is loaded with noxious principles, which the heat of the sun during the day had caused to ascend into the atmosphere. The disagreeable odour conveyed to us in mists is owing to the power of the aqueous fluid in transmitting the exhalations arising from the earth. The manner in which the air conveys to us the perfume of plants, and the odour which it contracts from the exhalations of bodies in a state of decomposition, indicate clearly its influence in producing maladies, and, still more plainly, its power of propagating those that are outrageous."

We shall not, at present, speak of the other matters which commingle in the atmosphere, as light,

heat, and electricity, but proceed to the improvement, and the application to rural affairs, of the facts already established.

WE MAY PROFIT BY THESE TRUTHS.

1st, *In selecting sites for our dwellings.*—Taking care to have them remote from marshes, ponds, and stagnant waters, which vitiate, by the exhalations they give, the atmosphere we breathe, and generate disease. The air in a small close room soon becomes vitiated by respiration and combustion, particularly if crowded, or heated by a close stove.

2d, *In the structure of our dwellings.*—In constructing ample apartments, open to ventilation, and in avoiding such as are low, moist, or inaccessible to the direct and healthful influence of the atmospheric air.

3d, *In improving our domestic habits.*—In improving cleanliness, an ancient, if not a modern virtue; in avoiding the deleterious influence of the night air, especially in autumn; in well ventilating our apartments when the weather is favourable, particularly early in summer mornings, when the air is pure and salubrious; in graduating the temperature of our rooms, which should not be suffered to rise above 64° of Fahrenheit; in avoiding hot sleeping apartments, in which the temperature often varies from 40 to 50 degrees between the hours of going to bed and the hour of rising, a transition too trying for the most robust constitution; in abandoning the use of footstoves, which transform our wives and daughters into delicate greenhouse plants, poison the air they respire, and beguile them into indolent and inactive habits, as detrimental to their health as it is to their usefulness; and in inducing our females to go warmly and tidily clad, even to the ball-room and *soirée*. How many human constitu-

tions are ruined in our cities by indulgence in habits, which these truths teach us to reform!

4th, *In multiplying shade-trees about our dwellings*, which serve to purify the air, abate the fever of summer heats, by carrying off a portion of the caloric with the moisture they exhale, and which are, withal, an embellishment and an evidence of good taste.

5th, *In the construction of our stables and cattle-sheds*.—Farm-stock, except, perhaps, the hog, are as sensitive to good air and cleanliness as man; and the same precautions which go to secure the health of the latter are essentially requisite to promote the well-being of the former. Hence the importance of having clean and well-ventilated stables and sheds, of removing the dung so that it does not undergo fermentation in their yards, and of giving them wholesome exercise.

6. *In the planting of our seeds*.—The atmosphere being essential to germination, all seeds should be deposited in the soil within its reach; they should be put just so low as will barely secure about them moisture enough to assist their germination. We have reason to think that small seeds are often deposited too low; and that, even if they germinate, the food which the cotyledons afford, and which is their only support till the seminal leaves are developed, is not sufficient to carry the plant to the earth's surface, where the leaves can alone exercise their office.

7. *In the management of our field and garden crops*.—The earths have a strong affinity for water, when pulverent and loose, but comparatively little when compact or crusted. In the former case they act like the sponge, transmitting the dews which fall upon them, and the food of plants with which they are impregnated, to the roots of vegetables. But where the earth is compact, or become incrustated by alternate rains and sunshine, the dews do not

penetrate, but are dissipated by the first rays of the morning sun. Hence the best preventive against the evils of drought is the frequent stirring of the surface, and keeping it constantly permeable to atmospheric air, and the vegetable nutrition with which it abounds. We remember a remarkable illustration of the utility of frequently stirring the surface of cultivated lands, detailed by Curwen, a distinguished British agriculturist. He prepared a field of stiff forbidding land, and planted it with cabbages. His neighbours all declared he would get no crop; but he put a horse and cultivator into it, and subjected it to almost constant stirring during the growing season. The result was, he gathered an immense crop, some of the cabbages weighing over fifty pounds each. The farmer may derive great benefit from this practice in the culture of drilled and hoed crops, provided he does not go so deep as to cut the roots of his plants, or throw his manure to the surface. And,

Lastly, we may profit from the facts we have detailed, *in the management of our manure*, the basis of fertility to our soils. The whole of the matter of dead plants and of animals is susceptible of being transmuted into the matter of living plants by the ordinary process of nature; and it is capable, however solid it may seem, of being reduced to liquid or gaseous forms. Indeed, it proceeds to take these forms immediately, on its losing its vitality, as soon as it comes in contact with air, heat, and water, the great agents of decomposition. The moment manures begin to ferment, the waste of vegetable food begins; carbonic acid gas is disengaged, and is scattered by the winds; the oxygen of the atmosphere, uniting with the hydrogen of the mass, forms water, which settles into the ground or is carried off by rains; and the mass is reduced in volume, and when fermentation has exhausted its force, it has lost one half of its fertilizing properties. If the ferment-

tation takes place in the dungyard or upon the field, this half is lost to all useful purposes for the farm. If it takes place in the soil, the earth imbibes it, and the plants growing thereon are fed and nourished by it; the grasses and liquids are converted into the solid matter of the growing crop.

We have thus endeavoured briefly, though we fear but imperfectly, to illustrate some few of the benefits which may result to the farmer from an acquaintance with physical science. We may renew the subject hereafter.

* Sir Charles Bell.

PRACTICAL HUSBANDRY.

INTRODUCTION.

Tillage.

Go to work the right way.—I am sorry there is so much need of the admonitions I am about to give. Depend upon it, you do not "*work it right*," or you would make your farms just twice as valuable as they now are. Many of you *farm too much*. You would find it much more profitable to farm twenty acres well, than forty by halves. The last season I made my grounds produce at the rate of one hundred bushels of Indian corn to the acre. Is this not much better than a common crop of thirty or forty bushels? You will certainly say it is, and with the same breath ask how I manage to make it produce so plentifully. My land being much infested with ground mice or moles, and overrun with grubs and other vermin, I put on, early in the month of March, about seven bushels of salt to the acre, which thoroughly destroys all kinds of vermin, being an excellent strong manure, and ploughed and harrowed the ground over and over until it became completely mellow. I then had every corn-hole filled with long manure; and after dropping my corn (which had previously been soaked in warm water), I scattered a pint of lime over very hill, and then covered the whole with a little mellow earth. In about a week the corn began to come up plentifully; after which I nursed it with the plough and hoe every other week for eight weeks, at which time it was as high as my head, and not a spire of

it was destroyed, either by frost, grub, or birds. My other things I manured equally well, and I have been amply paid for all my extra care and trouble, as I raised more than twice as much per acre as any of my neighbours, and did it in much less time. I mean, I got all my harvesting done two or three weeks before many others. This is accomplished, in a great measure, by redeeming time : rising between three and four o'clock in the morning ; then, if the day be sultry and hot, I lie by from twelve to three, and rest : I then feel refreshed, and able to work till quite dark. This I call "*working it right* ;" whereas, should I lay in bed until the sun be up and shame me, haunt the tavern at night, drink too much whiskey, but half manure, half plough, half plant, half nurse, half harvest, and do everything by halves, I surely should not "*work it right*," nor get half a crop.

I shall now conclude by giving you, for farther consideration, a few excellent observations, from a wiser head, perhaps, than my own, and hope that every brother farmer will do likewise.

"I often say to myself, what a pity it is our farmers *do not work it right* ! When I see a man turn his cattle into the road to run at large, and waste their manure during a winter's day, I say that man *does not work it right*. Ten loads of good manure, at least, is lost in a season by this slovenly practice ; and all for what ? For nothing, indeed, but to ruin his farm.

"So, when I see cattle, late in the fall and early in the spring, rambling in a meadow or mowing field, pounding the soil and breaking the grass roots, I say to myself, this man *does not work it right*.

"So, when I see a barnyard with a drain to it, I say this man *does not work it right* ; for how easy it is to make a yard hollow or lowest in the middle, to receive the moisture and all the wash of the sides, which will thus be kept dry for the cattle.

The wash and moisture of the yard, mixed with any kind of earth or putrid straw, is excellent manure; yet how much do our farmers lose by neglecting these things! In fact, *they do not work it right.*

"When I see a farmer often going to a retailer's store with a bottle or jug, or lounging about a tavern, or wrangling about politics, or quarrelling and defaming his neighbour's good name, I am certain such a man *does not work it right.*"—*Providence Republican Herald.*

CHAPTER XII.

Rotation of Crops.

As crops of the cultivated plants succeed to each other upon the same ground, a question to be determined is the order in which the different kinds should follow each other.

All plants which are cultivated, and which are carried from the ground where they are produced, tend to render the soil less productive, or, in the language of farmers, to exhaust it.

But plants which are suffered to decay, or which are consumed by animals on the ground on which they grow, do not exhaust the soil. On the contrary, the decay of the stems and leaves of such plants, either naturally or by the consuming of them by animals, tends to add those decomposing organic matters to the soil which form one of the elements of its fertility. This process may be imperceptible and slow, but it is that which Nature herself employs to form the soil, as distinguished from what has been termed the subsoil.

Sometimes this process of decay is counteracted
Vol. I.—N

by the singular natural provision of a conversion of the decomposing vegetables into a substance which itself resists decomposition, peat. But with this exception, the tendency of the decay of vegetables upon the surface is to add to the fertile matters of the soil.

This is well understood in the practice of agriculturists. When the productive powers of a soil have been exhausted by cultivation and the carrying away of its produce from the surface, it is laid down to herbage, in which state the future vegetation which it produces tends, by its decomposition upon the surface, to renovate the productive powers of the soil. Land in this state is said to rest.

When land, however, has been impoverished by successive crops, and has become full of weeds, the laying it down to rest in that state is attended with less beneficial consequences than when the soil has been previously cleaned of injurious weeds, and fertilized by good culture. In the former case, the process of renovation is slow, if perceptible at all; the useless plants increase, and not those which are beneficial, and afford food to pasturing animals. Land, when properly laid down to grass, therefore, tends to recover its wasted powers of production. Land not properly laid down has less of this healing property, and may be more full of weeds, and no richer when ploughed up again after a time than when laid down. Under good management, however, the laying down of cultivated land to grass and other herbage-plants to be consumed upon the ground, is a means of resting the soil and renovating its powers of production; and this mode of recruiting an exhausted soil being always at the command of the farmer, its application is important in practice. It is to be observed, also, that the poorer soils require this species of rest and renovation more than those which are naturally productive.

The experience of husbandmen, from the earliest

times, has shown that the same kinds of plants cannot be advantageously cultivated in continued succession. The same or similar species tend to grow feebly, or degenerate, or become more subject to diseases, when cultivated successively upon the same ground, and hence the rule which forms the basis of a system of regular alternation of crops is, that plants of the same or similar species shall not be cultivated in immediate succession; and farther, the same rule has been thus far extended, that the same species shall recur at as distant intervals of the course as circumstances will allow.

All herbaceous plants, whose produce is carried off the ground which produces them, may be said to exhaust the soil upon which they grow. But all such plants do not exhaust the soil in the same degree; for after some species the soil is seen to be more impoverished than after others.

And not only do different species of plants exhaust the soil in a greater or less degree than others, but the same species does so according to the different period of its growth at which the plant is removed from the ground.

When a herbaceous plant is suffered to mature its seeds, it exhausts the soil more than when it is removed before its seeds are matured. All herbaceous plants, therefore, when cut in their green state, that is, before they have matured their seeds, exhaust the soil less than when they remain until they have ripened their seeds. Thus the turnip, when used in its green state, is one of the least exhausting in the agricultural class of plants to which it belongs: but the turnip, when allowed to remain upon the ground until it has ripened its seeds, is one of the most exhausting plants that is cultivated among us; and so it is with the rape and others.

Farther, certain plants, by the larger or smaller quantity of manure which the consumption of them afford, are more or less useful in maintaining the fertility of the farm.

When an herbaceous plant is suffered to mature its seeds, and when any part of these seeds is carried off the farm, the plant affords, when consumed by animals, a smaller return of manure to the farm than if the same plant had been cut down before it had matured its seeds, and been in that state consumed by animals. Thus it is with the turnip-plant referred to. This plant is, with us, sown before midsummer. In the first season it forms a napiform root, and puts forth a large system of leaves. Early in the following season it puts forth a long stem, which bears flowers, and the seeds are generally matured about midsummer. If this plant is removed in the first stage of its growth, that is, after it has put forth its large leaves and formed its bulb, and is then consumed by animals, it returns a great quantity of manure; but if it remains until the second state of its growth, then the consumption of its stems and leaves returns scarce any manure. The juices of the root have apparently been exhausted in affording nutrition to the flower-stem, the flowers, and seeds.

It is beyond a question, that, in order to bring a plant to its entire maturity by the perfecting of its seeds, a larger quantity of the nutritive matter of the soil is sucked up by it than when it is brought only to its less advanced stages. When crops of plants, therefore, are suffered to arrive at maturity, they are greatly more exhausters of the soil on which they grow than when they are cut down while they are green; and if those seeds are in whole or in part carried off the farm, the crops are exhausters of the farm, as well as of the ground which had produced them. Were the ripened seeds to be wholly returned to the soil, it may be believed that they might give back to it all the nutritive matter which had been derived from it. But, in practice, seeds are employed for many purposes, and are generally carried off the farm which produces

them. When this is done in whole or in part, the plants produced are in an eminent degree exhausters of the farm, as well as of the soil on which they have grown.

Farther, certain plants, from their mode of growth and cultivation, are more favourable to the growth of weeds than other plants. The cereal grasses, from growing closely together, and not admitting, or admitting partially, the eradication of weeds, are more favourable to the growth and multiplication of weeds than such plants as the turnip and the potato, which are grown at a considerable distance from each other and admit of tillage during their growth, and whose broad system of leaves tend to repress the growth of stranger plants.

Having these principles in view, certain rules may be deduced from them for the order in which the crops of plants in cultivation in a country shall succeed to each other on the same ground.

1st, Crops consisting of plants of the same or similar species, shall not follow in succession, but shall return at as distant intervals as the case will allow.

2d, Crops consisting of plants whose mode of growth or cultivation tends to the production of weeds, shall not follow in succession.

3d, Crops whose culture admits of the destruction of weeds, shall be cultivated when we cultivate plants which favour the production of weeds. And farther, crops whose consumption returns to the soil a sufficient quantity of manure, shall be cultivated at intervals sufficient to maintain or increase the fertility of the farm.

And, 4th, when land is to be laid to grass, this shall be done when the soil is fertile and clean.

These rules may be applied to the plants which form the subject of common cultivation in the fields. In this country, the plants chiefly cultivated on the large scale are : the cereal grasses, chiefly for the

farina of their seeds ; certain leguminous plants, as the bean and the pea ; plants cultivated for their fibres, as the flax and hemp ; for their leaves, roots, and tubers, as the turnip, the cabbage, and the potato ; and certain leguminous and other plants for forage or herbage. The plants of these different classes are yet to be described ; and they are now only referred to with relation to the order in which they may succeed to each other in cultivation. The 1st class of these plants consist of the cereal grasses. These are chiefly wheat, barley, oats, and, partially, rye. All these plants are, in an eminent degree, exhausters of the farm. They are all suffered to mature their seeds, and are wholly or partially carried away from the farm. Farther, from the manner of their growth and mode of cultivation, they all tend to favour the production of weeds. For these reasons, and on the general principle that plants of the same or similar kinds should not follow in succession, the cereal grasses should not succeed each other, but should be preceded or followed by some crop which either exhausts the soil less, or admits of a more perfect eradication of weeds.

2d, The leguminous plants cultivated for their seeds, as the bean and the pea, are all exhausters of the soil.* They ripen their seeds, and the seeds are for the most part carried off the farm. Some physiologists suppose that they are less exhausters of the soil than the cereal grasses. But the essential difference between them, when considered with relation to their effect upon the soil, is that, from their growth and the manner of cultivating them, they are greatly less favourable to the production of weeds than cereal grasses. By their broader system of leaves, they tend to stifle the growth of weeds more than the cereal grasses ; and farther, they admit of tillage during a great part of their

* Indian corn may be included in this class of plants.—Cult.

growth. This is especially the case with the bean [and maize], which is therefore regarded as a useful cleaning crop, and so is cultivated in rotation with the cereal grasses, as a means of preserving the land clean.

3d, Hemp and flax, which are cultivated for their fibres, and all plants cultivated for their oils, are exhausters of the soil. They are suffered to form and ripen their seeds, and their stems afford no return of manure to the farm.

The next class of plants, from the large return of manures which the consumption of them affords, may be regarded as enriching or restorative crops, in contradistinction to the others, which may be termed exhausting crops :

1. The turnip, the rape, and other plants of the cabbage genus, cultivated for their roots and leaves, and consumed upon the farm.

2. The potato, the carrot, the parsnip, the beet, and other plants cultivated for their tubers and roots, and consumed upon the farm.

3. The leguminous plants, the clover, the tare, the lucerne, and others, when cut green for forage, and consumed upon the farm.

The plants of the latter class, namely, the leguminous, when mixed with gramineous plants, as the rye-grass, are commonly termed the artificial grasses, but would be more correctly termed the cultivated herbage or forage plants. They are often suffered partially to ripen their seeds, and are made into hay; and in this case they follow the general law, exhausting the soil more than when used green. And when the hay-crop is carried away from the farm, they are to be regarded as exhausting rather than restorative crops.

In speaking of these different classes of plants, the following terms may be employed :

1. The cereal grasses may be termed Corn-crops.

2. The leguminous plants cultivated for their seeds, Pulse [and maize] crops.

3. The turnip, and other plants of the same kind, cultivated for their roots and leaves, may, with reference to their mode of consuming them, be termed Green crops; or, with reference to the manner of preparing the ground for them, Fallow-crops.

4. The potato, and plants of other families cultivated for their roots and tubers, may, in like manner, be termed Green or Fallow crops.

5. The leguminous plants cultivated for green food, as the lucerne and tare, may be termed Green Forage-crops.

And, lastly, the mixture of gramineous and leguminous plants cultivated for herbage or green feed, may, in compliance with common language, be still termed the Sown or Artificial Grasses.

Farther, distinguishing these different classes of crops according to their effects upon the fertility of the farm, they might be divided thus:

1. Corn-crops—exhausting crops, and favourers of weeds.

2. Pulse-crops—exhausting or cleaning crops, or capable of being rendered so.

3. Green or fallow-crops—restorative and cleaning crops.

4. Green forage-crops—restorative and sometimes cleaning crops.

5. The sown grasses—restorative crops.

Knowing these the general characters of the cultivated plants, we have, in devising a rotation, to cause the restorative and cleaning crops so to alternate with the exhausting crops, as that the land may be preserved fertile and clean. Farther, when we find that land cannot be sufficiently cleaned by means of cleaning crops, we must make use of the summer-fallow; and again, when we find that land requires rest, we may lay it down to grass for a longer or shorter time, taking care when this is done

that the land shall be in as fertile a state as circumstances will allow, and free from weeds.—*Low's Elements of Practical Agriculture.*

The Genesee Farmer on this subject remarks, "We find a great deal said in English publications of the importance of a rotation of crops; and although we may receive, and, doubtless, do receive, many valuable hints from our transatlantic brethren, yet their soil, their climate, their markets, and price of labour are so different, as to render it highly improper for the American farmer implicitly to follow their directions. Indeed, it would be imprudent to follow the directions of the best farmers of New-England, for the good reasons that our most valuable products, as well as our soils, are different. In western New-York the soil is well adapted to wheat. It is the great staple. To that the farmer looks to supply him with money. That mode of farming, therefore, which produces this crop in the greatest perfection, is the one he ought to pursue. It is well known that land may be too rich for wheat, and that the application of barnyard manure immediately preceding a crop of wheat is considered by the best farmers injudicious. I am in favour of an alternation of crops, and have found the following to answer best on my farm, which is considered a good wheat soil.

"Indian corn is a gross feeder; indeed, it is impossible to make land too rich for it; I therefore give my corn and potato ground all the manure I can collect; and if the corn be planted early, and well tended, it may be cut and drawn off in season for wheat, and the ground put in a good state to receive it by one ploughing. If, however, the farmer have sufficient ground for wheat without it, the better method is to put on barley or pease next season, and, as soon as the crop is taken off, give the ground a thorough harrowing, which will cause the seeds that may have dropped to vegetate, in which state it should be left till near the time of seeding, when

one good ploughing will be better than more. Then run a light harrow over it, which puts the ground in a better state to receive the wheat. Then harrow twice and follow with the roller, when every good farmer will strike water furrows. By this mode of management, all the vegetable matter which may have sprung up will be completely *buried in the soil*, and there remain to enrich it.

"Few farmers occupy as many acres with corn, potatoes, and ruta бага, as they wish to sow with wheat. If the system of clovering is pursued (which I recommend to every farmer), I deem naked fallows unnecessary. A good sward turned in, after plastering—if a heavy soil, in the fall; if light, in the spring—rolled, and then harrowed, will put the ground in a fine state for pease, barley, or oats. Immediately after the crops are taken off, proceed as above directed, and, if the land be in good heart, we may safely calculate on a good crop of wheat. If the land be rich, I have frequently taken a second crop of wheat before seeding with grass, equally heavy with the first.

"This mode cannot be profitably pursued unless the land is rich; and if not so, green crops ploughed in will make it so. I have this year turned in a heavy crop of buckwheat in blossom, in a field exhausted by the previous occupant. I then sowed wheat, and shall give it at least ten pounds of clover-seed per acre early in the spring, and then plaster.

"Some of the best farmers of Pennsylvania assert that calcareous land may be made to produce heavy crops of wheat for several successive years, by means of clover and plaster sown every year; and where the farmer raises his own clover-seed, he may sow it in the chaff, and find the method profitable, not only as it relates to crops, but, what is equally important, his land is continually growing richer. I have not given this method a trial, but intend to do it. If found to succeed, it will go

to establish a fact not yet settled, that clover restores to the land the principles yielding starch and gluten, without which wheat cannot perfect itself. This fact once established, the farmers of our western country will raise of other crops no more than may be necessary for their own consumption.

"I saw the last of five successive crops of wheat growing in the calcareous soil on the east bank of Cayuga Lake, which was estimated to yield 25 bushels per acre. If, then, this soil, managed as in Pennsylvania, actually furnishes the pabulum of wheat, may we not draw the conclusion that such soils only as are primitive, or are destitute of lime, require a regular rotation of crops."

Alternating crops.—The present season has afforded a good opportunity of testing the utility of alternating tillage and grass crops: for, so far as our observation has extended, meadows of similar quality of soil have been productive in an inverse ratio to their age, i. e., the longer they have been in grass, the lighter the product. In some instances, the difference has been three to one in favour of the new-stocked lands. The more than common difference apparent the present year we ascribe to the want of heavy rains in the last autumn, winter, and spring. The light rains penetrated more readily grounds which had recently been under the plough, and which were comparatively porous and pulverent, than they did those which were rendered in a manner impervious, and which had remained for years undisturbed by the plough. But if grass greatly deteriorates, grains do much more so, without heavy dressings of manure and the alternation of roots. Tillage is admirably fitted to pulverize, clean, and prepare the soil for grasses; and grass leys are equally beneficial to tillage crops, by the vegetable matter—the food—which they give to the soil. We always suspect, that the man who advertises his farm as "suitably divided into plough, meadow,

and pasture land," pursues the old platform system, and that he knows nothing of the immense advantages, particularly upon sands, gravels, and loams, which result from a judicious system of alternate husbandry. We do not wonder that such a farmer, nowadays, should be obliged to sell his farm. Pastures, as well as tillage and grass crops, are augmented in value by the alternating system. There are districts which form an exception to the rule; but, generally, every acre of a farm, which is not a rock, may, by thorough drainage, be rendered capable of yielding grain, grass, or pasture; and the interests of the cultivator would be promoted by subjecting them to this alternation.—*Ed. Cult.*

CHAPTER XIII.

Comparative Advantages of Naked Fallows and Fallow Crops.

Remarks on putting in Small Grain on Stubble Ground.—The worst system in cultivation in common practice seems to be stubbling in, or annually putting in crops of small grain on stubble grounds. This is too generally practised everywhere, but especially in the backwoods, until weeds and poverty of soil united reduce the product so much that the crops fall far short of remunerating the cultivator for the labour bestowed on them. When this happens, he generally resorts to a naked fallow. This is too often badly executed. Still, many of the weeds that would have choked and robbed the plants of much nutriment, are destroyed; consequently, the product is increased in proportion to the food remaining in the soil and the cultivation bestowed on it.

A degree of merit is justly due to a Naked Fallow executed in the usual way.—A naked fallow is certainly a very laborious and injurious practice. It is also equally certain that any soil may be much better prepared for a succeeding crop of wheat, or any other small grain, by a fallow crop properly ordered. Still, a naked fallow should be allowed all the merit justly due to it, especially by those who mean to controvert that practice.

When it is well executed, the soil is finely divided. The animal and vegetable matter, which was before locked up in hard clods of earth, impervious to the roots of the plants, is brought into more immediate use. The enriching and fertilizing matter floating in the atmosphere is more freely absorbed and better secured by an open, free soil, than when it rests on one of a contrary description. The roots of the plants are also enabled to dip deeper and spread wider through the soil in search of the nutriment provided for them. It is true, if the ground be very sandy, a naked fallow, by opening the texture, makes it less fit for the roots of the plants, and causes much injurious evaporation from it; likewise, when an adhesive clay has been finely pulverized, heavy rains, succeeded by a hot sun or drying winds, cause it to bake and become impervious to the roots of plants; but, except the advantage derived from the shade of the fallow plants, the same happens both in clay and sand, when the soil is prepared for small grain by a fallow crop cultivated in the usual way.

Jethro Tull, the ingenious inventor of the drill husbandry, grew exhausting crops annually on the same ground, without the aid of manure, although his soil seems to have been thin.

Sir H. Davy says, "Jethro Tull, in 1733, advanced the opinion, that minute earthy particles supplied the whole nourishment of the whole vegetable world; that air and water were chiefly useful in

producing these particles from the land." If Sir H. had quoted the words of this truly great but very mistaken agriculturist, the question would have been determined. Some years have elapsed since I read Mr. Tull's book on agriculture. If my memory be correct, he attaches more consequence to the depositions from the atmosphere than Sir H. seems to imagine; and appeared to believe they were conveyed to the soil by the dews. However, Mr. Tull's practice alone is sufficient to determine, that vegetation is greatly promoted by dividing the soil, particularly when the cultivation is extended to the growing crops. The practice of ages clearly shows, that much more is to be expected from a naked fallow than too many advocates for fallow crops seem to believe. Still, if Mr. Tull had lived until he had divided the soil sufficiently often to have extracted the animal and vegetable matter that the undivided clods contained; also, to have decomposed the hard vegetable substances which are always more or less seen, in greater or smaller quantities, in all soils, his opinion respecting enriching manures would have been greatly altered; as was that of Mr. Duhamel, a distinguished agriculturist of the same school, but who lived long enough to see the fallacy of this inconsiderable theory, and also to abandon it.

The disadvantages arising from that practice considered.—Having candidly stated every advantage that seems to be derived from a naked fallow, I will enumerate the very serious disadvantages and injurious consequences arising therefrom.

It is an expensive practice: First, the loss of one full year's rent of the soil. Secondly, it must be frequently ploughed, harrowed, and rolled. After this, it often happens that much annual labour is necessary to break the clods, especially when they are firmly bound together with the roots of the grasses and weeds. These are pushed about by the plough, dragged by the harrow, and sunk into

the soil by the roller, but not sufficiently separated by any of them. The remains of them, together with the more finely-divided grasses and weeds, are dragged up into heaps by the harrow throughout the whole field. These are raked up into larger heaps and burned by some cultivators. Others suffer them to remain, and, when the seed is sown, the harrow, by dragging the heaps, drags up much of the seed with them; and vegetation is destroyed wherever they may happen to lie. In either case, a great waste of vegetable matter takes place; for, when it is not burned, its best properties are exhaled by the sun or scattered in the air. Numbers of men, women, and children are sometimes seen in England breaking the hard-matted clods into pieces, raking them up into heaps, and burning this very valuable vegetation, which, without any of this enormous waste of labour, might have been very profitably applied to the growth of the crops and improvement of the soil. After the utmost care has been taken to prepare a naked fallow in the usual way, a multitude of the roots and tops of the grasses and weeds remain so intimately mixed within the soil, that they will grow in sufficient numbers to do great injury to the crop, especially if the weather happens to be dripping during the process of cultivation. In that case, the moisture preserves the vegetative powers of the grasses and weeds, and the crop is sure to be much injured by them.

The seeds of the weeds are as often turned under as uppermost by the usual mode of cultivation; consequently, many of them do not vegetate during the process; and those that are buried beyond the power of germination, when the small grain is sown, will grow and injure the crop. If dung is applied for the small grain, it is generally spread previously to seeding, and turned under by a shallow furrow; of consequence, it produces a plentiful crop of weeds; for although the cooks of dung say that

the fermentation of it destroys the vegetative property of seed, practice and observation determine the contrary.

In fact, if nature had not calculated seeds in general to withstand much more than the heat of a fermenting dunghill, the earth would long since have been stripped of vegetation, particularly where ploughers and croppers reside. Like the locust in Egypt, they would soon destroy every green thing, if nature had not reserved seeds for ages unhurt, with which she carefully counteracts so much of the injury done by this class of farmers as to prevent actual sterility from taking place in the grounds cultivated by them.

The usual mode of cultivating Fallow Crops contrasted with the practice recommended by the author.— Although it is granted that a naked fallow prepares much food for plants by finely dividing the soil, frequent ploughing and harrowing are calculated to scatter much animal and vegetable matter in the air, especially while the soil is exposed to the injurious effects of the sun and air; unless the bad effects produced by this process be counteracted by excellent management in other respects, it will eventually ruin the soil. If this practice be pursued, under the best mode of management that superior talents can devise, the improvement in the soil will be slow indeed when compared with that which may be readily effected by the practice of fallow crops properly ordered. It is also evident, that in the latter case the grounds are profitably employed, while in the former they yield nothing, although the farmer is spending much money in the very laborious cultivation of them.

No improvement made in agriculture has promoted the interest of it so extensively as the introduction of fallow crops. Yet it seems evident, that the various different modes which have been generally pursued in the cultivation of these crops, as

well as in that of the cultivated crops following them, are by no means calculated to promote the product of either, or to enrich the soil to anything like that extent which might be readily effected, with much less labour and expense, if a proper system of cultivation were pursued. If, however, distinct parts of the very numerous and discordant systems of cultivation be selected from the different practices that are commonly pursued by different cultivators, it appears that nothing is offered by me which has not been more or less sanctioned by the actual practice of others. Therefore, the merit of my system of husbandry does not consist in overturning what the practice and observation of ages have introduced, but in uniting into one system such practices as are consistent with nature, reason, and common sense, rejecting those only that seem to be inconsistent with either. The undertaking is arduous, especially when ventured upon by a plain practical farmer, who depends not on science, but on nature, reason, practice, and observation. In a work of this sort, errors are to be expected; still, as these errors cannot be capital, but little injury is to be expected from them before they may be corrected by those who are better informed.

Observations on the value of Grass lays, and the proper cultivation of them.—Agriculture will never reach its zenith until the value of grass lays is sufficiently appreciated, and the cultivation of them much better understood. The value of a clover lay, when applied for wheat, is well known. Still, most farmers continue frequent mowing or close pasturing until the clover is nearly run out. This greatly impoverishes the lay, and, unless the soil be rich, the wheat crop is light. The clover plant cannot withstand frequent cutting, even during the first season it is mown. This causes the lateral roots of the plants to become weak, and incapable of holding the tap-roots in the ground; and they are thrown

out by the frosts of the ensuing winter and spring. The same happens if red clover be pastured, unless a well-grown covering of the tops of the grass be preserved, especially to defend the roots and crown of the plant from the frosts of the ensuing winter and spring. If this plant be thus defended, it will far better withstand, not only the frosts in winter and spring, but also the injurious heat of the sun.

The Red Clover Plant is destroyed by frequent mowing and close pasturing.—Both red clover and spear-grass lays are very justly esteemed by many farmers as the best preparation for a fallow crop of maize. Some, either to save labour, or from a just conviction that the value of the crop is also greatly increased, do not turn the sod in the cultivation of the fallow plants. Too many of them, however, as well as other cultivators, believe the health and vigour of the plants are greatly promoted by harrowing over them while they are young. Some, also, use harrows with sharp cutting tines, for the purpose of cutting through the sod deeply, and as near to the stems of the plants as may be conveniently done without cutting or tearing up. These practices are certainly opposed to the economy of nature and the enlightened reason of man. None of these gentlemen would wound, bruise, or mangle a young animal, to increase the health and vigour of it; neither would they rend and tear the choice trees in their nurseries to make them grow better; although less evil would arise from mangling them, as trees are calculated much better to withstand and outgrow this very manifest injury. The practice of mutilating the tops, and separating the roots of plants from their stems, for the express purpose of causing them to grow much more luxuriantly, is not confined to maize; potatoes and other hardy plants, that are capable of withstanding this truly barbarian practice, are too often subjected to it.

Fermentation, properly directed, is the mainspring

of Vegetation.—Although some farmers do not turn up the sod in the cultivation of maize, all of them, so far as my observation extends, plough it up previously to seeding the small grain that follows this plant. This exposes the rich matter arising from the fermentation of the roots and tops of the grasses, and the dung also, if that has been applied, to a serious waste. It is exhaled by the sun, scattered in the winds, and washed away by the rains and melting snows. Fermentation, which is the main-spring of vegetation, is checked. None of these evils happen when the small grain is put in by a superficial cultivation, as the rich fertilizing matter remains securely buried within the soil. This nature applies, with the least possible loss, to the use of the cultivated crops and the grasses following, and with the overplus she enriches the soil. The fermentation and decay of this enriching matter more effectually expands and minutely divides the soil than can be done with the plough. The plough, harrow, and roller, with, too often, the addition of very expensive manual labour, are capable of pulverizing the soil to any desirable extent. After this has been done, it settles, and too often becomes impervious to the roots of the plants, unless the ground be so rich that it is not materially affected by the loss of the animal and vegetable matter which always takes place when the soil is cultivated in the usual way.

It should also be recollected, that every crop which is sown broad cast principally depends on the expanding force of fermentation to keep the soil open and mellow for the ready admission of the roots of the plants; likewise, that, when the grain is filling, the plants require the most nutriment; and that, previously to this, the soil is consolidated by time, unless it has been kept open and mellow by the fermentation of the animal and vegetable matter contained in it, or consists principally

of sand. In the latter case, the lack of animal and vegetable matter causes much injurious evaporation of moisture. This, if the season does not happen to be dripping, greatly reduces the product of the ground.—*Lorraine.*

CHAPTER XIV.

Culture of Wheat.

THERE are two causes which, when our winters are open, operate injuriously on wheat crops. One is, the high and dry winds which prevail in March; these blow off the soil in many situations, and, by leaving the roots of wheat exposed, occasion their destruction. Another cause is, the heaving of the soil, occasioned by the alternations of cold and warm weather. The water in the soil, in the act of freezing, expands and raises up the earth, and also the roots of the wheat-plants which the earth embraces; when a thaw succeeds, the earth being heaviest, falls down first, and leaves the roots of wheat a little elevated, and, by repeated changes of the weather, the roots are so far thrown out as to perish.

Farmers, when convenient, usually sow their winter grain early in September, upon a supposition, which guides their common practice, that grain thus early sown withstands best the action of unfavourable seasons. This supposition is founded upon the very plausible theory that, as the oldest roots will be longer and more numerous, and take a firmer hold of the soil than those which are younger, they will be the least exposed to be thrown above it, and, at the same time, from their greater strength,

be more tenacious of life. But experience informs us that wheat, sown as late as the first or even the second week in October, very often survives with less injury than that which is sown in the early part of September. Indeed, farmers very generally admit, as the result of their experience, that rye, whose laws of vegetation must be nearly the same as those of wheat, sown so late in the season as barely to come up, is likely to withstand an unfavourable winter. Still the very plausible theory which has been mentioned very generally induces them to sow rye early as well as wheat, in direct opposition to conclusions which have been drawn from actual observation.

An experiment was made last autumn for the purpose of collecting some farther information on this subject. On the first day of September last I excavated a spot of ground six feet square. On the one side the excavation was about six inches deep, on the opposite side its depth did not exceed one inch. Seed-wheat was placed over the bottom, so that the kernels were about four inches distant from each other; the excavation was then filled up. There was a suitable mixture of gravel, sand, and clay for wheat, and of ordinary fertility. This was the latter part of the extreme drought which prevailed last summer, and the soil was dry, warm, and finely pulverized before it was thrown on the wheat. These circumstances, except the extreme dryness of the soil, were highly favourable to the vegetation of seed at the greatest depth in the earth. On the fourth of the month there was a heavy shower, which not only wet the soil, but beat it down close and hard. On the ninth of the month the plants began to show themselves, but none came up from a greater depth than about three and a half inches. Two or three days after the second leaf had displayed itself, some of the roots were taken up and examined. It now appeared that nearly an inch be-

low the surface of the ground a new joint was found, which was the basis of the second leaf, and also of a new system of roots. There were now two tiers of roots; the seed or knot adjoining it had generated the lower tier, and the new joint the upper one. These two tiers or systems of roots were connected together by a root resembling a cord or thread; and in one instance I cut off this connecting thread, and transplanted the upper part. This grew, with little apparent check from its curtailment; but the under part died, although the soil above it was opened so as to afford it the advantages of air and solar heat. On the 20th day of September I examined another plant, which had its two regular formations as expected, and, what was not expected, a blade was discovered about an inch long, which had started from the lower system of roots, and would doubtless have found its way to the surface had it not been disturbed. It is to be remarked, that this plant sprang from seed placed under cover of nearly four inches of soil, which was about an inch deeper than any of the other plants examined, and that some of the tops of the wheat-plants had been eaten off and trodden down by accidental intrusion; a fact unregarded at the time. On the 26th day of September I examined another root, expecting to see the blade from below more perfectly developed; none, however, was discovered; but a third tier of roots was found at the surface of the ground, which proceeded from the second as that had from the first system of roots. On the 16th day of October I placed some seed-wheat about two inches in the ground; their delay in coming up induced me to suppose that they had perished from cold and wetness; but at the expiration of three weeks they made their appearance, and, although the ground remained open several weeks longer, no second leaf appeared: of course no joint or second system of roots had been formed. The very differ-

ent formations in the roots of wheat which this experiment has disclosed, proceeded from causes appropriate, and capable of being ascertained; but, to distinguish them with certainty, other trials must be made, and conducted with greater accuracy than the one of which an account has been given.

From these experiments, though inaccurate, some conclusions may perhaps be drawn of practical use. All plants which live over winter possess an apparatus by which they supply themselves in autumn with food for their sustenance in spring. This food consists mostly of saccharine matter, which is enclosed in a proper receptacle. When this receptacle is formed near the surface of the earth, the fermentation of its contents is excited by frequent changes of weather; the saccharine matter is decomposed, and the plant perishes from the want of food, and perhaps, also, from the rupture of its vessels.

All wheat shallow sowed must have its reservoirs of food but slightly covered with soil, and of course they are fully exposed. When wheat is sown early at any depth, a second, and sometimes, at least, a third system of roots is formed, within an inch of the surface. In these many stems originate, each of which has its receptacle of nourishment at its base; and it is quite certain that in most instances the food which was contained in the seed and the adjoining knot is entirely exhausted by the supplies of nourishment it affords the upper portions of the plant. The life of early-sowed wheat must, then, like that which is shallow sowed, depend upon the preservation of the reservoirs of saccharine matter which are placed at or near the surface of the ground, and, of course, exposed to the unfavourable action of variable weather during winter.

Wheat which is late sowed generates no second blade or new system of roots, and, of course, the

nourishment for spring's use is retained in the receptacle which adjoins the seed. If, then, we sow sufficiently late in autumn, and place the seed deep in the soil, we shall provide every security against the hazards of bad weather which the nature of the case admits of.

In the ordinary course of husbandry, some of the wheat is necessarily deposited at considerable depth in the soil; and when this takes place sufficiently late in the season, the receptacle of food will be protected by its covering of earth, and a partial crop will often be realized, although there may be, when the spring opens, no signs of life on the surface of the field. As such cases as the destruction of the blade, which issues from the seed-roots in autumn, can be of little importance, one would suppose that the surviving plants would grow the more vigorously from their being less in number, and, by tillering, produce many stems, with large well-filled ears: such, however, is not the fact; usually the stems are single, and the heads are not large. To account for this, it must be recollected that, after the ground has thawed in spring, the earth settles, and often becomes so extremely hard that doubtless many plants die in their struggle to overcome the opposing resistance; and the surprise is that any should possess vigour enough to protrude even a single stem through the hard earth that covers it.

From this view of the subject, the practice may be recommended of effectually harrowing the field in the spring after the ground has settled, in order to supply the plant with fresh air and give a free passage to its upward growth. After the harrow has been used, the roller ought to be employed to reset such roots as have been displaced, and diminish the evaporation of moisture.

In England, a wheat-plant was taken up, separated into eighteen parts, and replanted, and, by successive divisions and replantations, a crop of three and

one third pecks of wheat was obtained in less than eighteen months from the time the seed was sown. If the roots of wheat can be so minutely divided and successfully replanted, there is little danger that the freest use of the harrow can be injurious, provided the roller be also used. The fact appears to be, that nothing is necessary to the vernal growth of plants but the preservation of the apparatus which contains the saccharine matter, which is its proper vernal food; so that if the roots and top be cut off, and the bulb be planted in a genial soil, the plant will grow.

Notwithstanding the arguments which have been urged in favour of sowing wheat late, it must be conceded that, when early sown, and our fields are cultivated in the usual manner, it produces the largest crop, if it survive the cold season. Whether such improvements may not be made as to combine the benefits of a sure and large crop, is a question still open to discussion: the probability is, that both advantages may be secured by a more correct knowledge of the proper time to sow, and of the best methods of culture.

In the first volume of "Transactions of the Society for the Promotion of Agriculture, Arts, and Manufactures," instituted in the State of New-York, it is stated that in Huntington, Suffolk county, fifty-two bushels of wheat had been raised by manure on an acre of land; and Mr. Downs is stated to have raised on a poor, gravelly, dry soil, by the use of fish as a manure, at the rate of 128 bushels of rye an acre. In this case, the rye would doubtless have lodged and been of little value, were it not that it was twice eaten off by his neighbour's sheep, which broke into the lot; once when the rye was nine inches high, and again when it was about six inches high.

The production of so large a crop of wheat and of rye must have proceeded from causes which are

steady and uniform in their operation; and if all the circumstances which had occurred to produce them had been distinguished and noted down, similar crops might have been again raised. Some things which occurred during the cultivation of this rye crop may be ascribed to accident or chance, so far as Mr. Downs's sagacity was concerned; but the causes which proximately occasioned the crop did not work by accident or by chance, but agreeably to laws or rules from which they never deviate. This uniformity of operation lays the foundation for making future discoveries, and brings within the grasp of our faculties the knowledge of increasing our crops by methods the least laborious and expensive.

The period may arrive when the farmer shall pursue his methods of culture with an anticipation of the consequences which will result analogous to that of the mechanician in the construction of a machine, and when, by direct means, he shall procure greater crops than ever were obtained by mere empirical trials.

Time was when the greatest philosophers taught the doctrine, that all things pertaining to the surface of the earth were too irregular and too much under the governance of chance to admit of scientific inquiry: this error has, within the last two centuries, been dispelled. But a similar error in regard to rural affairs is embraced by almost all our practical farmers; and the task of correcting and exposing it is devolved, it would seem, upon the unaided efforts of a few individuals. Here, then, is the difficulty.—*H. Hickock.*

CHAPTER XV.

Culture of Indian Corn.

THERE is no crop more beneficial to the American farmer than Indian corn. An eminent agriculturist, the late John Taylor, of Virginia, called it the "meal, meadow, and manure" of the farm. It is convertible into human food in more forms than any other grain; its value in fattening domestic animals is not exceeded by any product of the farm; and no crop returns more to the soil than this does in the form of manure. There are two important requisites, however, to its *profitable* cultivation. The first is, that the soil be adapted to its growth; and the second, that the crop be well fed and well tended; for food and attention are as important to the plant as to the animal. Ordinarily speaking, it costs less to take care of a good crop of corn, on proper corn land, than it does of a bad crop on land not adapted to its culture. The first is light and dry. The latter stiff, wet, or grassy. I put the average expense of cultivating and securing an acre at \$15 (*a*), including a fair rent, though it ordinarily exceeds this sum. The farmer, therefore, who obtains thirty bushels from the acre, estimating the grain at 50 cents per bushel, gets a fair compensation for his labour and the use of his land. Whatever the product falls short of this is an absolute loss, and whatever it may exceed it is nett gain. Thus the man who gets but twenty bushels from the acre, loses, upon this estimate, \$20 worth of his labour on four acres. He who raises 80 bushels an acre, on the other hand, realizes a nett profit of \$100 from four acres; making a difference in the profits of the two farmers in the management of four

acres of corn, of *one hundred and twenty dollars!* These data are sufficiently accurate to show the importance of the two requisites I have suggested, and the value of a little calculation in the business of farming. The habit of noting down the expense, as well as the product of a crop, and thus ascertaining the relative profit and loss, is highly advantageous to the practical farmer, and one which cannot be too strenuously inculcated. It will perhaps be said, that I ought to add the value of the manure which is employed in the large crop; but I reply, that I offset this against the increased forage which this crop furnishes. Besides, by applying the manure in the unfermented state in which it is generally found in the spring, it will be as beneficial to the succeeding crops as though it had lain and fermented in the yard, and been applied in the usual way in the autumn (b).

The soils adapted to the culture of Indian corn are such as are permeable to heat, air (c), and the roots of the plant, and embrace those denominated sandy, gravelly, and loamy. Corn will not succeed well on grounds that are stiff, hard, or wet. The roots grow to as great length as the stalks, and the soil must be loose to permit their free extension.

The manures used are generally yard and stable dung, and plaster of Paris (*sulphate of lime*). The first ought to be abundant; as upon the fertility which it induces depends the profit of the crop. Long or unfermented manure is to be preferred. It decomposes as the wants of the plant require it; while its mechanical operation, in rendering the soil light and porous, is beneficial to the crop. It should be equally spread over the whole surface before it is ploughed under. It then continues to afford fresh pasture to the roots till the corn has matured, and is, in its place, to benefit the succeeding crop. If put into the hills, the roots soon extend beyond its influence, it does not so readily decompose, and the

subsequent crop is prejudiced from its partial distribution in the soil. In a rotation of four or five years, in which this crop receives the manure, twenty-five or thirty ordinary loads may be applied to *one* acre, with greater profit than to *two* or *three* acres. Every addition tells in the product; and there is scarcely any danger of manuring too high for this favourite crop. Gypsum is applied broadcast before the last ploughing or harrowing, or strewed on the hills after hoeing. I pursued the first method, at the rate of a bushel to the acre (*d*).

The best preparation for a corn crop is a clover or other grass lay or lea, well covered with long manure, recently spread, neatly ploughed, and harrowed lengthwise of the furrow. A roller may precede the harrow with advantage. The time of performing these operations depends upon the texture of the soil and the quality of the sod. If the first is inclining to clay, or the latter tough or of long continuance, the ploughing may be performed the preceding autumn; but where sand or gravel greatly preponderate, or the sod is light and tender, it is best performed in the spring, and as near to the planting as convenient. The harrow, at least, should immediately precede planting. All seeds do best when put into the fresh-stirred mould. Stiff lands are ameliorated and broken down by fall ploughing, but light lands are rather prejudiced by it. When corn is preceded by a tilled crop, the ground should be furrowed, and the seed deposited in the bottoms of the furrows. Where there is a sod, the rows should be superficially marked, and the seed planted upon the surface. Where the field is flat or the subsoil retentive of moisture, the land should be laid in ridges, that the excess of water which falls may pass off in the furrows.

The time of planting must vary in different districts and in different seasons. The ground should be sufficiently warmed by vernal heat to cause a

speedy germination. Natural vegetation affords the best guide. My rule has been to plant when the apple is bursting its blossom buds, which has generally been between the 12th and 20th of May.

Preparation of the seed.—The enemies to be combated are the wire-worm, brown grub, birds, and squirrels. Of these the first and last two prey upon the kernels, and against these tar offers a complete protection. I soak my seed 12 hours in *hot* water, in which is dissolved a few ounces of crude salt-petre. When the corn has been thus soaked, I take for each half bushel of seed half a pint of tar, put it into an iron vessel with water, and heat it till the tar is dissolved, when it is turned upon the seed in steep. The mass is well stirred, the corn taken out, and as much plaster added as will adhere to the grain. This impregnates and partially coats the seed with the tar. The experience of years will warrant me in confidently recommending this as a protection for the seed.

The manner of planting is ordinarily in hills, from two and a half to six feet apart, according to the variety of corn, the strength of the soil, and the fancy of the cultivator. The usual distance in my neighbourhood is three feet. Some, however, plant in drills of one, two, and three rows, by which a greater crop is unquestionably obtained, though the expense of culture is somewhat increased (e).

The quantity of seed should be double, and may be quadruple (f) what is required to stand. It is well known that a great difference is manifest in the appearance of the plants. Some appear feeble and sickly, which the best nursing will not render productive. The expense of seed, and the labour of pulling up all but three or four of the strongest plants in a hill, it is believed, will be amply remunerated by the increased product. If the seed is covered, as it should be, with fine mould only, and not too deep, we may at least calculate upon every hill or drill having its requisite number of plants.

The after culture consists in keeping the soil loose and free from weeds, which is ordinarily accomplished by two dressings, and in thinning the plants, which latter may be done the first hoeing, or partially omitted till the last. The practice of ploughing among corn, and of making large hills, is justly getting into disrepute : for the plough bruises and cuts the roots of the plants, turns up the sod and manure to waste, and renders the crop more liable to suffer by drought. The first dressing should be performed as soon as the size of the plants will permit, and the best implement to precede the hoe is a corn-harrow, adapted to the width of the rows, which every farmer can make. This will destroy most of the weeds and pulverize the soil. The second hoeing should be performed before or as soon as the tassels appear, and may be preceded by the corn-harrow, a shallow furrow of the plough, or, what is better than either, by the cultivator (*g*). A slight earthing is beneficial, provided the earth is scraped from the surface, and the sod and manure not exposed. It will be found beneficial to run the harrow or cultivator a third, and even a fourth time, between the rows, to destroy weeds and loosen the surface, particularly if the season is dry (*h*).

In harvesting the crop one of three modes is adopted, viz., 1. The corn is cut at the surface of the ground when the grain has become glazed or hard upon the outside, put immediately into stooks, and, when sufficiently dried, the corn and stalks are separated, and both secured. 2. The tops are taken off when the corn has become glazed, and the grain permitted to remain till October or November upon the butts. Or, 3. Both corn and stalks are left standing till the grain has fully ripened, and the latter become dry, when both are secured. There are other modes, such as leaving the butts or entire stalks in the field after the grain is gathered ; but

these are so wasteful and slovenly as not to merit consideration. The stalks, blades, and tops of corn, if well secured, are an excellent fodder for neat cattle. If cut, or cut and steamed, so that they can be readily masticated, they are superior to hay. Besides, their fertilizing properties as a manure are greatly augmented by being fed out in the cattle yard, and imbibing the urine and liquids which always there abound, and which are lost to the farm, in ordinary yards, without an abundance of dry litter to take them up. By the first of these methods, the crop may be secured before the autumnal rains; the value of the fodder is increased, and the ground is cleared in time for a winter crop of wheat or rye. The second mode impairs the value of the forage, requires more labour, and does not increase the quantity or improve the quality of the grain. The third mode requires the same labour as the first, *may* improve the quality of the grain, but must inevitably deteriorate the quality of the fodder. The corn cannot be husked too promptly after it is gathered from the field. If permitted to heat, the value of the grain is seriously impaired (i).

Sowing seed.—The fairest and soundest ears are either selected in the field, or, at the time of husking, a few of the husks being left on, braided and preserved in an airy situation till wanted for use.

In making choice of sorts, the object should be to obtain the varieties which ripen early and afford the greatest crop. I think these two properties are best combined in a twelve-rowed kind which I obtained from Vermont some years ago, and which I call Dutton corn, from the name of the gentleman from whom I received it. It is earlier than the common eight-rowed yellow, or any other field variety I have seen, and, at the same time, gives the greatest product. I have invariably cut the crop in the first fourteen days of September, and once in the last week in August. The cob is large, but the

grain is so compact upon it that two bushels of sound ears have yielded five pecks of shelled grain, weighing 62 lbs. the bushel.

In securing the fodder, precaution must be used. The butts become wet by standing on the ground, and if placed in large stacks or in the barn, the moisture which they contain often induces fermentation and mouldiness. To avoid this, I put them first in stacks so small that the whole of the butts are exposed upon the outer surface; and, when thoroughly dry, they may be taken to the barn, or left to be removed as they are wanted to be fed out, merely regarding the propriety of removing a whole stack at the same time.

NOTES.

(a) *Estimated expense of cultivating an acre of Indian Corn.*

One ploughing (suppose a clover lay)	.. .	\$2 00
Harrowing and planting	.. .	2 00
Two hoeings, 4 days and horse team	.. .	3 75
Harvesting, 2 days	.. .	1 50
Cutting and harvesting stalks	.. .	1 50
Rent	.. .	5 00

\$15 75

(b) Stable and yard manures lose 50 per cent. by the fermentation they undergo in the yard during the summer. This loss consists of the gases which are evolved in the process of rotting, and of the fluids which sink into the earth, or are carried off by the rains. Plants receive their food either in the gaseous or liquid form. If manure rots in the soil, neither these gases or fluids are lost: the earth retains, and the roots of the plants imbibe them. Yet recent manures are not proper to be applied to small grains. They cause too rank a growth of straw, and are apt to induce rust and mildew. Thus a crop of corn, potatoes, or ruta бага, may be *fed* and *fattened*, if I may use the expression, upon the dung which is destined to nourish the wheat crop,

without deteriorating its value for the latter purpose, if it is applied to the corn, &c., before it has fermented.

(c) We are on the northern border of the maize zone, and should make up for defect in climate by selecting soils into which the heat readily penetrates. Air, besides conveying warmth in summer, imparts fertility by the vegetable food which is always suspended in it in the form of gases. Dews are also charged with these properties of vegetable nutriment, and, when the soil is porous, they settle down as in a sponge, and give food to the roots (the true mouths) of plants.

(d) I adopt the opinion of Davy as to the *modus operandi* of plaster of Paris, that it forms a necessary constituent of plants which it benefits, and is of no direct benefit to plants which do not afford it on analysis. Among the first are the clovers, corn, potatoes, and, generally, such plants as have broad or succulent leaves; while the latter embrace culmiferous grains and grasses, as wheat, rye, timothy, &c. Critical observation for years has confirmed me in this conclusion. Gypsum must be rendered soluble before it can be taken up by the mouths of plants, and it requires 600 parts of water to dissolve one of this mineral. I infer from these facts, that by burying it in the soil, it more readily dissolves, and is more accessible to the mouths of plants than if spread upon the surface of the ground. I am induced, from these views of the subject, to sow plaster on grass grounds in March, and upon corn and potato grounds before the last ploughing for these crops. The latter was recommended and practised by the distinguished agriculturists, the late John Taylor of Virginia, and Judge Peters of Pennsylvania.

(e) The following table exhibits the difference in product of various methods of planting, and serves also to explain the manner in which large crops of

this grain have been obtained. I have assumed in the estimate, that each stock produces one ear of corn, and that the ears average one gill of shelled grain. This is estimating the product low; for while I am penning this (October), I find that my largest ears give two gills, and 100 fair ears half a bushel of, shelled corn. The calculation is also predicated upon the supposition, that there is no deficiency in the number of stocks, a contingency pretty sure on my method of planting.

	Hills.	bush.	qts.
1. An acre in hills, 4 feet apart each way, will produce	2722	42	16
2. The same, 3 by 3 feet	4840	75	20
3. The same, 3 by 2½ feet	5808	93	28
4. The same, in drills at 3 feet, plants 6 stalks, 1 inch apart in the drills	29,040	113	14
5. The same in do., 2 rows in a drill, 6 inches apart, and the plants 9 inches, and 3 feet 9 inches from centre of drills, thus	30,970	120	31

6. The same in do., 3 rows in a drill, as above, 3 feet from centre of drills	43,560	170	5
---	--------	-----	---

The fifth mode I have tried. The ground was highly manured, the crop twice cleaned, and the entire acre gathered and weighed accurately the same day. The product in ears was 103 baskets, each 84 lbs. nett, and 65 lbs. over. The last basket was shelled and measured, which showed a product on the acre of 118 bushels 10 quarts. I gathered at the rate of more than 100 bushels the acre from four rods planted in the third method last summer, the result ascertained in the most accurate manner. Corn shrinks about 20 per cent. after it is cribbed. The sixth mode is the one by which the Messrs. Pratt, of Madison county, obtained the prodigious

crop of 170 bushels per acre. These gentlemen, I am told, are of opinion that the product of an acre may be increased to 200 bushels.

(f) I am told the Messrs. Pratt, above alluded to, used seven bushels of seed to the acre, the plants being subsequently reduced to the requisite number.

(g) The cultivator is made in the form of a triangular harrow, with two bulls; or, if intended to be graduated to different widths, a centre bull is added, to which the exterior ones are attached by hinges. Iron slats, fixed to the exterior bulls, pass through a mortice in the centre one, perforated with holes, through which an iron pin passes to hold them at the graduated width. The teeth may be in any approved form or reasonable number. The cultivator I use has five teeth, two in each of the outward, and one upon the centre timber. The teeth have a stout shank, with a duck's-foot termination, four inches broad, somewhat cylindrical, rounded at the point, and inclined forward in an angle of 30 or 40°. This implement is used for other purposes; and may be used, like Beatson's, as a substitute for the plough, in preparing light soils for a crop. The handles are attached to the centre piece. The teeth have a shoulder on the under side of the timber, and are fastened with screws and nuts above.

(h) Some entertain a mistaken notion, that it is prejudicial to stir the soil among corn in dry weather, and others that weeds serve to prevent the evaporation of moisture by a hot sun. The reverse of these opinions is true. The exhaustion of moisture by a plant is in the ratio of the surface of its leaves and stocks presented to the sun and air.

(i) The leaves are the necessary organs for elaborating the food of plants, and when these are taken away the plant must cease to grow. The sap is useless until it undergoes elaboration in the leaves. Hence, when corn is topped in the usual way, the supply of food is cut off from the grain, except

what may be elaborated in the husks. On comparing corn gathered by the first and second modes, it was the opinion of those who assisted in husking, that the first was soundest, brightest, and heaviest. The third mode I have not tried. But it seems probable, that the grain might acquire an increase of volume, though it would lose again by depredation and waste. The first method has these farther advantages, that it preserves the cob from being saturated with rains, and secures the fodder when it is in its highest perfection and greatest quantity.

—J. Buel.

Cutting the stalks.—For a few years past I have not cut my cornstalks until the corn was harvested, *guessing* that it was a course preferable to the one commonly pursued in this part of the country, of topping the stalks while in a green state. But for the purpose of settling this point more clearly, and with as little trouble as the case would admit, I selected, about the 5th of September, a row of corn in a field of about five acres, intending to take one that would average in quality equal to the field throughout, that I might, at the same time, be able to ascertain, with tolerable certainty, the product of the whole field. The manure having been spread on the surface of the ground, and harrowed in lengthwise of the furrows, and the corn planted across the furrows, made it apparently less difficult to select an average row. On this row I cut the stalks from half the hills; beginning at one end, and cutting the first hill, then leaving the next uncut, and so proceeding alternately, cutting one, and leaving the next uncut, through the row. I had intended to confine the experiment to this row, but finally was led to extend it so far as to include four rows; and, numbering them agreeably to the order in which they were standing in the field, this row may be called No. 2. There were ninety-two hills in the row, and the stalks were cut from forty-six hills,

VOL. I.—Q

all of them in the manner that is here termed jointing, i. e., cut off between the ear and the first joint above the ear. I thought they were somewhat more ripe than is usual at the time of cutting; a few of them were nearly dry. The soil was a sandy or gravelly loam, anciently covered with pine, oak, and chestnut. In hoeing the corn, no hills were made, but some care was taken that the surface of the ground should remain as level as possible through the season.

My estimate of the number of hills on an acre was made in the following manner; and, if I am wrong in my calculations, I shall be corrected by some of your readers.

In an area of 200 feet square (or 40,000 square feet), there were sixty-two rows, with fifty-four hills in a row, making 3348 hills. This is equal to 3646 hills per acre, each hill occupying nearly twelve square feet of surface. There were about four stalks of corn in a hill. In estimating bushels, I have allowed the lawful weight of fifty-six pounds to the bushel.

At the time of harvesting, the corn was husked in the field. The forty-six hills from which the stalks had been cut, gave forty-eight and a half pounds of ears: and the forty-six hills on which the stalks had not been cut, gave sixty-two pounds of ears. The number of ears in the two cases was about the same; those from the uncut hills were evidently the best filled out and the most hale; on a large proportion of them the kernels were so closely wedged in as to make it difficult to bend the ear at all without breaking it. There was very little mouldy corn in either case; a few ears were gathered, mostly from the cut stalks, but the whole quantity was so small as to make it questionable whether cutting the stalks had much effect in this particular.

Both parcels were carefully laid aside in a dry

chamber for about six or eight weeks, at the expiration of which time they were again weighed, and the parcel of ears from the uncut hills had lost in drying about two per cent. more than the other; affording some evidence that the sap continued to circulate for a greater length of time in the uncut than in the cut stalks. The uncut hills gave 42 lbs. 8 oz. dry shelled corn, equal to 14 oz. 12 1-2 grs. per hill, or 60 bushels and 8 pounds per acre. The parcel from the cut hills gave 33 lbs. 7 oz., equal to 11 oz. 10 grs. per hill, or 47 bushels and 18 pounds per acre; making a loss of 12 bushels and 46 pounds per acre by cutting the stalks; conclusive evidence that, while the sap is in circulation, nature does not assign the stalks an unprofitable office. The product of this whole row, taken together, cut and uncut hills, was equal to 53 bushels and 41 pounds per acre.

The product of row No. 3, taken by itself (containing ninety-two hills, on one half of which the stalks were cut on the same day the others were), would not show the practice of cutting stalks quite so destructive in its effects as that exhibited in row No. 2. Its whole produce was 77 lbs. 9 oz. dry corn, equal to 55 bushels and 10 pounds per acre, or 1 bushel and 25 pounds per acre more than row No. 2.

Not satisfied with resting the experiment here, I gathered the corn on rows Nos. 1 and 4, i. e., the rows each side next adjoining Nos. 2 and 3, and on which none of the stalks had been cut. These rows, taken together, contained 186 hills, and their product of dry shelled corn was 171 lbs. 13 oz., equal to 14 oz. 12 1-2 grs. per hill, or 60 bushels and 8 pounds per acre, precisely the same average yield as that part of row No. 2 on which the stalks had not been cut. This *exact* coincidence, however, I think may be numbered among those cases which rarely happen.

The difference between the two rows on which

half the stalks were cut, and the two rows on which none of the stalks were cut, was 5 bushels 38 1-2 pounds per acre. If this difference arose from cutting half the stalks (and I know of no other reason), then cutting the whole would have reduced the crop 11 bushels and 21 pounds per acre, or from 60 bushels and 8 pounds to 48 bushels and 43 pounds per acre.

To recapitulate, row No. 2, on which the experiment was commenced, taken by itself, is as follows, viz., 46 hills, on which the stalks had *not* been cut, gave 42 lbs. 8 oz. dry shelled corn, equal to, per acre, ... 60 bush. 8 lbs.
46 hills from which the stalks *had* been cut, gave
33 lbs. 7 oz. dry shelled corn, equal to, per
acre, ... 47 " 18 "

Loss by cutting the stalks, per acre, ... 12 " 46 "

The four rows, taken together, stand as follows :

Nos. 1 and 4, on which no stalks were cut, gave
an average of, per acre, ... 60 bush. 8 lbs
Nos. 2 and 3, from which half the stalks were
cut, gave an average of, per acre, ... 54 " 25½ "

Loss by cutting one half the stalks per acre, ... 5 " 38½ "

On cutting all the stalks, would make a loss
equal to, per acre, ... 11 " 21 "

The difference in the result of the two cases is 1 bushel and 25 pounds per acre; or in the two experiments (if it may be so termed) there is an average loss, by cutting the stalks, of 12 bushels 5 1-2 pounds per acre; a loss quite equal to all the expense of hoeing and harvesting, especially when we consider that, in hoeing, the labour of making hills was dispensed with.

If I had cut all the stalks, and obtained a crop of forty-eight bushels to the acre, the very fact of having forty-eight bushels would, I think, be considered by farmers generally, in this section of the country, as proof positive that the stalks were cut without injury to the crop. Or, if I had gone one

step farther, and made large hills, at an additional expense of one dollar per acre, and thereby reduced the crop to forty-five bushels per acre, the forty-five bushels would be considered sufficient proof that making hills (which, by-the-way, are usually made equally large and high on wet or dry land, without regard to soil or situation) was labour well laid out. For although you occasionally give us a *large corn story*, swollen a little, perhaps, by *guessing* it off in *baskets*; yet, judging from what we see and know about raising corn, we call forty-five bushels per acre a good crop.

A measured bushel from the cut hills weighed 57 lbs. 6 oz., one pound less than from the *uncut*; the shrinkage being very near equal to the whole loss in weight.

If this experiment is a fair test, it seems *that about twenty per cent., or one fifth part of the crop, is destroyed by cutting the stalks in the way they are usually cut.* If farther experiment should establish this fact, I think there are few farmers that will hesitate long in deciding which is the most valuable, one acre of corn or five acres of top stalks. But this twenty per cent. is not saved at the expense of losing the stalks; they are worth as much, and, I think, more, all things considered, after the corn is harvested, than they are gathered in the usual way. If, after being bunched up in a green state, they heat or become mouldy (a case of frequent occurrence), they are utterly worthless, except it be for manure; I know of no animal that will eat them. But, after they have once been dried by the frost and wind, a subsequent moderate degree of mouldiness seems to be no injury.

The course which I have pursued with them, and for the present I know of no better, has been as follows: In the first place they are cut off near the ground, and for this purpose a short scythe is found the most convenient instrument. The expense of

cutting in this manner, however, is but a mere trifle, if any, more than cutting the stub stalks in the spring, and may, with propriety, be entered as an item of expense against the next crop, for which it is preparing the ground. After cutting, they are gathered into bunches of suitable size for binding, and three good sheaves of rye straw, if wet, will be sufficient to bind a ton. In gathering them up and laying in bunches, an active boy will do as much as a man. In this way, the whole expense of gathering, binding, and loading will not exceed 75 cents per ton. As they are very bulky, for want of barn room, I have them stacked near the barnyard; and I think I may safely say that my cattle eat more pounds of stalks from an acre gathered in this way, than they would from the same acre if gathered in the usual way. It may be objected to this, that they are not as good and nourishing as others: as to that matter, I am not able to say; but, if the cattle are good judges in the case (and I think they ought to be admitted as such), they are quite as good and quite as nourishing, for they are eaten apparently with quite as good a relish. In addition to this, they are obtained without breaking off ears or breaking down hills in hauling out, occurrences quite frequent in the other case. They also furnish more than double the quantity of bedding for the yard, an item of no small moment in the list of "creature comforts" during our cold winters. And last, though not least, they make more than double the quantity of manure, the value of which will be duly appreciated by every good farmer without argument. It may be said that the butt stalks can be gathered after harvest, and furnish the same quantity of litter and manure as in this case. That is true; but the expense of gathering both parts in that way, from the butts being so short and inconvenient to bind, would be three times as much as it is to gather them whole. Thus

viewing the subject in various points, I think this method of managing cornstalks is much better than the old one; and that a little observation and experience will convince the most skeptical that this branch of agriculture is not yet brought to a state of perfection; that there is yet room for improvement.—*J. Ely.*

REMARKS.

I very much regret that Mr. Clark did not carry his experiments one step farther, and ascertain the relative weight of forty-six hills cut with the entire stalks at the time he topped his No. 2. It would have decided whether the stalks afford nutriment to the grain after they are separated from the roots, and to what extent. This last has been my method of harvesting my crop, from an impression that I lost by it nothing in the weight of the grain, while I gained much in the quantity and quality of the fodder. The objection that the stalks mould is not tenable. They will not mould while the corn is upon them, if tied above the ears. And if not sufficiently dry when the corn is picked, they may be left in stacks till perfectly cured, and yet be housed in far better condition than they are by the ordinary mode of saving them. It is not the drying that deteriorates their value for fodder, but the *drenchings* which they get when left out till the corn is picked, and the frosts, which diminish very much their nutritive properties. If well cured, and especially if cut and steamed, cattle eat them freely, and I consider them no wise inferior to hay. The grain from the crop secured in my way has weighed sixty and sixty-two pounds the bushel. It is a twelve-rowed, early variety, which I denominate the Dutton corn.

I have remarked, that the modes of planting corn, or, rather, the distance between the plants, is different in different states. In New-England, the dis-

tance is greater than in New-York, and greater in Pennsylvania than in the former. Mr. Clark's hills were four by three feet, which gave him 3646 hills, or, by my estimate, 3630 on the acre. Our Mr. Stimson plants at two and a half feet each way, and gets upon the acre 6969 hills, or nearly double what Mr. Clark does. I once planted an acre in drills, two rows in a drill, the plants six inches apart in the rows, the rows six inches apart, and three feet between the centres of the drills, quincunx, and had, if there were no vacancies, 30,970 stalks, equal to 7742 hills on the acre. The ground and entire product were accurately measured and weighed. While the Messrs. Pratt, of Madison, produced 170 bushels on the acre, by planting in drills, three rows in each, quincunx, thus, * * * * and four feet from the centre of the drills. If the rows were six inches apart, and the plants nine inches in the rows, the plants amounted to 43,065, equal to 10,890 hills. Assuming as data, that in all the above-cited cases each plant produced an ear of corn, and that the ears averaged one gill of shelled grain, their product would be as follows in bushels and quarts:

Mr. Clark's,	.	.	.	56 bushels, 13 quarts.
Mr. Stimson's,	.	.	.	108 " 24 "
My own,	.	.	.	120 " 31 "
Messrs. Pratt's,	.	.	.	170 "

The close planting, whether in hills or drills, requires high manuring, and the two and three rowed drills extra labour; and the ears may, withal, be somewhat smaller. Yet I nevertheless believe that seventy or eighty bushels may be obtained on an acre, with good manuring on a genial soil, in our mode of planting, with about as little labour as twenty, thirty, or forty bushels are obtained in the New-England or Pennsylvania open method.

I have detailed the preceding facts and calculations, not with a view to vaunt of our skill or of the

fertility of our soil, but to *show how* the large crops of corn have been raised in this state, which have been noticed in the papers.

There is one fact connected with the experiment of the Messrs. Pratt worthy of consideration; there was not a plant missing or deficient in their field. They quadrupled their seed: and pulled up, as the character of the plants was developed, all but the requisite number, reserving the strongest and most promising. It is common to see cornfields very deficient in plants and even in entire hills. This deficiency often amounts to one fourth or one half. The loss incident to this defect may readily be estimated, and greatly counterbalances the expense of extra seed and the labour of thinning the plants.
—*Ed. Cultivator.*

CHAPTER XVI.

Culture of Potatoes.

Experiments in raising Potatoes.—Experiment 1.

—Mr. Robertson marked off, on an average portion of his potato ground, four drills, twenty yards each in length; in two of these he planted potato seed of the red-nosed kidney species, and in the remaining two of the apple kind. These he earthed up in the usual way: in these earthed drills the product was six pounds (about 10 per cent.) less than in four corresponding ones unearthed. In all those drills (which were 30 inches apart), the sets were placed from ten to twelve inches asunder. The treatment of the unearthed drills may be thus stated: They were dug at bottom twelve inches deep, and left half full of the crumbling clods; on these the potatoes were laid, and then covered about three inches

with dung, over which an inch of fine earth was drawn. When the shoots were sufficiently high, the clods were broken fine and closed about the stems, and the ground in the intervals dug deep and fine as possible, and left perfectly flat; this was the only tillage which the unearthed potatoes received. The produce was about 150 barrels* to the acre.

Experiment 2.—In order to determine at what distance in drills 30 inches apart, it is advantageous to plant the sets, Mr. Robertson proceeded as follows:

In a piece of ground of sixty square yards (not yards square), he planted eight drills of a new seedling cup potato at 30 inches distance; these drills, nearly 9 feet in length, he planted at the distance above stated, as follows:

Drill 1, the sets 9 inches apart, and 1 shoot left.

" 2,	"	6	"	"	2	"
" 3,	"	12	"	"	1	"
" 4,	"	12	"	"	2	"
" 5,	"	16	"	"	1	"
" 6,	"	16	"	"	2	"
" 7,	"	18	"	"	1	"
" 8,	"	18	"	"	2	"

The produce was—

						Bbls.	st.	lbs.
Drill 1	.	.	.	.	.	0	6	2
" 2	.	.	.	.	.	0	4	7
" 3	.	.	.	.	.	0	3	1
" 4	.	.	.	.	.	0	4	3
" 5	.	.	.	.	.	0	3	6
" 6	.	.	.	.	.	0	4	7
" 7	.	.	.	.	.	0	3	3
" 8	.	.	.	.	.	0	6	1

Gross Produce, . . . 1 15 2

Which is about 228 barrels, or 28 tons 10 cwt. to the Irish acre, accurately weighed. This enormous produce was from an alluvial soil, light and deep.

Experiment 3.—To ascertain the result of giving

* The Kilkenny barrel contains 20 stones of 14 lbs.; the total was therefore about 700 bushels.

unlimited room to the potato, and the depth to which the roots would run if unrestrained

On a piece of ground trenched upward of three feet, Mr. Robertson planted eight whole potatoes, each three feet apart in the row, with unlimited room to grow at each side. The produce was six stones, and the fibres were traced downward three feet, the space they occupied being equal to that of two drills in Experiment 2.

Experiment 1 proves the inutility of earthing.

Experiment 2 gives an interesting demonstration of the advantage of free access of air, the outside drills giving such superior produce; and the advantage (25 per cent.) of the double-stemmed ones over the single, at the same distance, proves (combined with the other circumstances) the truth of Mr. Knight's theory, that, in proportion to the abundance of its foliage, and the free access of air and light, will be the productiveness of the potato.

From the similarity of produce in the corresponding drills of Nos. 2, 4, and 6, and in Nos. 3, 5, and 7, it would appear of little importance at what distance the sets are placed in the drills, provided they have sufficient room to spread at each side; and the extent of this must be regulated by experience.

It is of the highest importance, however, that the ground should be deeply worked and highly pulverized: for the potato fibre is extremely delicate, and cannot penetrate through a hard, unyielding soil, though it will run freely through that which is loose, and occupy the pulverized intervals between the drills.

Mr. Robertson deems it highly absurd, in shallow soils, to heap on the top of the potatoes, where it affords no nutriment, the earth which, if left within the range of fibre, would feed it. However, it is to be remembered that *some species* of potatoes strike upward, *cups*, for instance (though it appears that Mr. Robertson used these in this experiment), and

in such case earthing is most probably useful. *Apple* potatoes have a downward tendency, and therefore may not require moulding. The species under culture, and the nature of the soil, should also materially influence the farmer as to the disposition of the manure under or over the set. It is obvious that (on a dry and porous soil in particular) in the culture of *cup* potatoes, the vegetating tendencies of which are to the surface, it is injudicious to place the manure under the sets.—*Q. Jour. of Agriculture.*

On Potatoes.—By T. A. Knight.—In a letter which I published last autumn, I stated that I had obtained a produce of potatoes equivalent to 887 1-4 bushels and 3 lbs. (each bushel weighing 60 lbs.) per statute acre, and I then expressed an intention, which I now fulfil, of pointing out the means by which such an extraordinary crop was obtained, and by which, of course, other crops of equal magnitude may be again obtained; and I look forward with confidence to obtaining in the present year a produce equivalent to 1000 bushels per acre of potatoes of first-rate quality.

The first point to which I wish to direct the attention of the cultivator of the potato is, *the age of the variety*; for it has long been known, that *every variety cultivated gradually becomes debilitated, and loses a large portion of its powers of producing; and I believe that almost every variety now cultivated in this and the adjoining counties has long since passed the period of its age at which it ought to have resigned its place to a successor.*

No variety should ever be cultivated which uselessly expends itself in the production of seeds, nor even of full-grown blossoms, unless it possesses some valuable redeeming qualities.

The distance of the intervals between the rows should be regulated wholly by the length required by the stems in each peculiar soil and situation. If the utmost length required by the stems be four feet, let the intervals between the rows be four feet also: and if the variety be of dwarfish habits, and its long-

est stem does not exceed two feet, intervals of two feet will be sufficient.

The rows should be made from *north to south*, that the midday sun may be permitted fully to shine between them, for every particle of living matter found in the tuberous root of the potato plant has been generated in the leaves (which act only when exposed to light), and has descended beneath the soil.

Each set should weigh *at least six ounces*; and they should never be placed at greater distances from each other than *six inches* from centre to centre, and a preference should be given to *whole potatoes*, when such can be obtained. If the growth of the plant be very dwarfish, four inches between the sets, from centre to centre, will be preferable; and if the form of the potato be long and kidney-shaped, a good deal of advantage will be gained by placing them to stand upon their ends, that end which joined the parent plant placed downward.

The largest produce will generally be obtained from varieties of rather early habits and rather low stature, there being in very tall plants much time necessarily lost in carrying the nutriment, which has been absorbed from the soil, up into the leaves and down again, in the state of living sap, to the tuber.

Varieties which have strong stems and erect form are to be preferred, because such are least subject to fall upon and shade the foliage of each other.

It is much more advantageous to incorporate the manure with the soil by means of the spade or plough, than to put it in with the sets; for, in the latter case, a large majority of the roots, during the summer and autumn, do not derive advantage from it.

Early planting is, under almost all circumstances, best; and the period, except for some very peculiar varieties, should never be later than the middle of the month of April.

VOL. I.—R

I possess, though at present in small quantities necessarily, many new varieties, which promise to prove valuable both on account of the quantity and quality of their produce, and I shall be happy, as soon as I have the power, to make them useful to the public. I obtained, in the last year, from some of these, under culture with the plough (the soil being shallow and naturally poor, and manure not having been given in more than ordinary quantity), a produce equivalent to more than 650 bushels of potatoes, of first-rate excellence, per acre, and a good deal larger produce from others of inferior quality, but I have not any reason to believe that I possess any variety which, either in quality for immediate human food, or in quantity for affording food to the inferior animals, has reached or ever approximated the greatest state of excellence which the potato is capable of acquiring.—*British Farmer's Magazine*.

Cut and Uncut Potatoes for Planting.—I planted this year alternate rows of cut and uncut potatoes. I put four pieces into each hill of the cut potatoes, and two potatoes into each hill of the whole potatoes. The hills were three feet apart each way, and, of course, the number of hills in an acre was 4840. The produce of the rows planted with cut potatoes was at the rate of three hundred and thirty-five bushels the acre, or twenty-three thousand five hundred and twenty pounds. The produce of the rows planted with whole potatoes was at the rate of four hundred and fifty-eight bushels, or thirty-two thousand and sixty pounds. The difference in the crop in favour of whole potatoes was at the rate of one hundred and twenty-two bushels the acre; but as there were twenty-two bushels more of seed to the acre used in planting the whole potatoes, the nett gain was only one hundred bushels. However, as one bushel of potatoes at the season of planting is usually worth two bushels at harvest-

time, it will be more accurate to calculate the gain at seventy-eight bushels. The kind of potatoes planted was the "*white blue nose*," which is decidedly the best potato for the table I have ever cultivated, though a moderate bearer, unless it receive generous treatment.—*New-England Farmer*.

The object of farmers generally is to plant those varieties which will give the greatest yield, without regard to flavour or nutritious properties. This is wrong. Potatoes differ one half in the nourishment they afford to domestic animals, as well as to man; and the eating of a *good* thing may be as grateful to the brute as to the man. It has been ascertained, by chymical tests, that one hundred parts of a good potato contain twenty-eight per cent., or twenty-eight parts, of nutritious matter, and that one hundred parts of some poor varieties contain not more than fourteen parts of nutritious matter. The man or the brute, therefore, that eats 100 lbs. of poor potatoes, swallows 86 lbs. of water and ligneous matter, which does not contribute in the least to nourish the body nor to promote health. If the crop is to be consumed in the family or on the farm, there is a propriety, on the score of economy, in selecting good sorts, though these do not yield more than half as many bushels as the poor sorts do. But the difference in product seldom, if ever, exceeds a quarter. For market, the difference between good and bad potatoes is, or ought to be, a quarter; and it will be, when the buyer knows how to appreciate and to distinguish the difference. The best varieties of potatoes now in vogue are the kidneys, or foxites, the pink-eyes, the Mercers, and the Sault St. Marie.

The potato requires with us a rich, moist, and cool soil; that part at least in which the tubers form to be loose, that the stolens may penetrate and the potatoes swell without much obstruction. A clover lay, and long manure, are particularly beneficial to

the crop. They should not be planted so close that the tops shall exclude the sun from the soil. Three feet in drills, or two and a half in hills, is near enough for ordinary varieties. Nor is it beneficial to earth them after the tubers have begun to form, as this removes the roots too far from the surface, and causes a new set of stolens to issue. Stolens are the roots on which the potatoes form, and are distinct from those which penetrate deep and supply food to the plant. But all weeds should be carefully destroyed; as one of these, if suffered to ripen its seeds, takes as much nourishment and moisture from the ground as a stem of the potatoes. This crop should not be planted twice on the same ground in succession, as the second year the product will be greatly diminished.

CHAPTER XVII.

Grasses—Clover, Lucerne.

On the culture of Clover.—Few things have contributed more largely to the modern improvement of husbandry than the introduction of clover, in connexion with the rotation of crops. This plant serves to ameliorate and fertilize the soil, and, at the same time, it affords an abundance of wholesome food for every description of farm-stock. Whether cut for winter stores, for soiling in the yard, or fed off by stock, but few crops surpass it in the quantity of cattle-food which it affords. Although cultivated in Holland and Flanders, from an early period, with great advantage, it was not introduced into Great Britain till the 16th century. At present, clovers enter largely into the succession of crops there, on

all soils, and in every productive course of management. They were principally instrumental in giving to Flanders its high celebrity as an agricultural country, greatly in advance, in improvement, of the states around it. The clover system has converted some of the poorest districts in England into the most productive and profitable. In the United States it is comparatively of recent introduction; and even at this day its benefits are but partially appreciated or applied as they ought to be. In connexion with gypsum, clover first became a subject of notice and culture in the counties about Philadelphia, and in the county of Dutchess, some forty years ago; and we are much indebted to the example and writings of Chancellor Livingston, Judge Peters, and other gentlemen of learning, opulence, and enterprise, for the improvement and wealth which it has conferred on our land. Many of our farmers have yet much to learn before they can realize the full benefits which it is capable of affording in the profits of the farm. Although botanists enumerate nearly fifty species of the clover family, our present remarks are intended to apply merely to the common red kind (*trifolium pratense*).

There are three faults in the management of clover, which we design briefly to notice, in reference to alternate husbandry. These are,

1. *Too little seed is usually sown.* The object of the clover crop is to procure a cheap food for animals and plants. Few if any crops surpass it in the quantity which it affords of these, and few exhaust the fertility of the soil less. One farmer sows four or six pounds of seed to the acre, and gets in return a thin but coarse crop of hay or pasture. Another sows ten to fourteen pounds, obtains double the burden of the first, and at a trifling extra expense of less than a dollar to the acre for seed, while his land is doubly benefited by the green crop to be ploughed in. From ten to fourteen pounds of seed should

be sown to the acre, whether the object be to benefit the stock or the land. The product will be somewhat in the ratio of the seed sown; and the advantages of heavy stocking, both in the hay and to the soil, will far outbalance the cost of the extra seed.

2. *Clover lays are permitted to remain too long before they are brought under the plough.*—The common clover is a biennial, or, at most, a triennial plant; and if not ploughed under before the third year, its advantages to the soil, as a green crop, are mostly or wholly lost; while after the second year, it adds very little to the crop of hay. But if turned under the first or second year, it furnishes to the soil a great quantity of vegetable matter, the true food of plants. It not only serves as manure, but it benefits mechanically. Its tap roots penetrate and divide the soil, and, as they decay, render it friable, and permeable to heat, air, and moisture. A well-set clover lay imparts to the soil as much benefit, in our opinion, as ten loads of yard manure to the acre. When a broadcast crop is to be followed by a hoed crop, as corn, potatoes, or small grain, there is manifestly a decided advantage in stocking it with clover, though it is to be turned under the ensuing fall or spring. We estimate its value, as manure, to say nothing of the pasture it affords, at from five to ten dollars per acre, while the cost of the seed does not ordinarily exceed one dollar. I have rye and clover upon a piece of poor sandy land, for which I had no manure to spare, three years in succession, with manifest advantage.

3. *The common method of curing clover hay is bad.*—The object to be obtained is to cure hay in the *cheapest and best manner.* The common practice of spreading clover from the swath, causes the leaves and blossoms to dry and crumble ere the haulm or stocks are sufficiently cured. Thus either the finer parts of the hay are lost, or the crop is housed with so much moisture, as to cause it to

heat, and often to spoil. Clover should only be spread when it has become wet with rain in the swath, and should be gathered again before the leaves dry and crumble. Both these evils may be avoided, and labour saved withal, by curing the grass wholly in swath and cock. After experiencing the serious disadvantages of the old method, I adopted the one I am about to recommend, and have pursued it satisfactorily ten or a dozen years. My practice has been to leave the clover to wilt in the swath, and when partially dried, either to turn the swaths or to make grass-cocks the same day, so as to secure the dried portions from the dew. That which is not put into cocks the first day is thus secured the second day, or as soon as it has become partially dried. These grass-cocks are permitted to stand one, two, or three days, according as the weather is, and as the curing process has progressed, when they are opened at nine or ten o'clock on a fair day, the hay again turned over between eleven and three, and, soon after turning, gathered for the cart. Thus cured, the hay is perfectly bright and sweet, and hardly a blossom or leaf is wasted. Some care is required in making the cocks. The grass is collected with forks and placed on dry ground between the swaths, in as small a compass as convenient at the base, say two or three feet in diameter, and rising in a cone to the height of four or five feet.

The advantages of this mode of curing clover are,

1. The labour of spreading from the swath is saved.

2. The labour of the handrake is abridged, or may be wholly dispensed with, if the horse-rake is used to glean the field when the hay is taken off; the forks sufficing to collect it tolerably clean in the cocking process.

3. It prevents, in a great measure, injury from dew and rain; for these cocks, if rightly construct-



ed (not by rolling), will sustain a rain of some days—that is, they have done this with me—without heating or becoming more than superficially wet.

4. Clover hay made in this way may almost invariably be housed in good condition; and if rain falls after the grass is mown, the quality of the hay is infinitely superior in cocks, to what it would be under the old process of curing.

The *rationale* is this: The outside of the clover parts with much of its moisture while in swath; and what is called sweating, in cock, is merely the passage of moisture remaining in the succulent stocks to their exterior, and to their leaves and blossoms; it is a diffusion, an equalization of the remaining moisture in the cock. When this has taken place, evaporation is greatly facilitated, and the whole mass acquires a uniform dryness, on opening the cocks to the influence of the sun and winds, if too long an exposure is guarded against. Evaporation progresses in the cocks after the hay is gathered for the cart, and during the operation of loading and unloading.

Clover will grow on pretty much all soils that have been laid dry by good drains. It is the basis of good farming, on all lands susceptible of alternate husbandry. Its benefits are threefold: it breaks, pulverizes, and ameliorates the soil by its tap-roots, and it furnishes a cheap food for plants as well as animals. A good clover lay is worth to a crop, by the food which it affords, as much as five tons of manure to the acre. To ensure a good lay, at least ten pounds of seed should be sown to the acre, and the ground well rolled. Its value, as food for plants, depends more upon the quantity of roots than upon the luxuriance of the stems, though the abundance of the latter will depend in a great measure upon the number of the former. To obtain the full value of this plant, we must cultivate it as a food for our *crops* as well as our cattle; and in this case we

should use it as such the first or second year before it has run out. There is economy in always sowing clover with small grains, though it is to be ploughed in the same or the next season. Ten pounds of seed cost, upon an average, one dollar; the labour of sowing is comparatively nothing. Its value to the next crop cannot be less than quadruple that sum, to say nothing of the feed it may afford, or its mechanical amelioration of the soil. We cannot avoid again urging a trial of the method of making clover hay *in cocks*, as we have heretofore recommended, notwithstanding the rebuke we have had upon this head from our esteemed friend and correspondent, Mr. Perkins. We have followed the practice twelve or fifteen years, and hence speak from experience, and with confidence, of its manifest advantages over the common method of spreading from the swath. Put it into small cocks with a fork from the swath, as soon as it is freed from external moisture or well wilted, and then leave it to cure. An hour or two exposure to the sun, previous to its being carted from the field, is all the farther care it will require. This mode saves labour, prevents injury from rain, and secures the hay in the best possible condition.—*Ed. Cult.*

Lucerne (*medicago sativa*), sometimes called French clover, may be advantageously cultivated on farms adapted to its growth, to be used either in *foiling* farm-stock, as cows, horses, pigs, &c., that is, to be cut and fed green in the yard or stable, or as auxiliary to pasture. No crop gives so great a product of forage during the summer, and all domestic animals are fond of and thrive upon it. It is in condition to cut from the 15th to 20th May, and will give three or four cuttings in a season. An acre of good lucerne will keep six cows well from the first cutting; and as soon as the whole has been cut over to supply this number with food, the earliest mown will be fit to cut a second time. I have

cultivated lucerne ten or a dozen years, and it has been almost my whole dependence for the summer support of my cows and a yoke of oxen. An acre has been worth to me fifty dollars a year. But to ensure a profitable crop, certain requisites are necessary, some of which I will name.

Lucerne must be sown on a dry soil.—The roots penetrate four to six feet, and these will neither grow nor live where there is water. Sand, gravel, or loam are the best soils for it.

It should be sown on a rich and clean soil.—Without the first the crop will be diminutive; and if weeds abound, they will rob and choke the young lucerne, which is feeble during its early growth. The best preparation for it is a crop of potatoes, well manured, and well cleaned in tilling.

Sow 16 pounds to the acre, broadcast, with half a bushel of winter rye, early in May, in ground well pulverized; harrow in the seed, and follow with the roller. Or the seed may be put in with a drill-barrow, at 12 to 18 inches between the drills, at the rate of 10 lbs. the acre, and in this case the intervals should be kept clean with the hoe or otherwise. The duration of lucerne is 6 to 10 years; though it sometimes, like clover, suffers from the winter.

To make lucerne into hay, it should lie in the swath to wilt, and then be put into small grass-cocks with a fork (not rolled) to cure. After standing a day or two, the cocks may be opened two or three hours under a bright sun, the hay turned, and soon after housed. If spread like ordinary grass, the leaves dry and crumble ere the haulm or stalks are cured, and thus the best part of the fodder is lost. I have mixed lucerne, partially cured, in alternate strata with dry barley-straw on the mow, and found that cattle greedily consumed both in winter, when fed out in the yard.

Lucerne may be sown till the 15th of May, at the

rate of sixteen pounds to the acre. The soil should be dry and loose, rich and clean, and the subsoil pervious, so that the tap-roots may extend down four or five feet, without encountering clay, hardpan, or water. Potatoes are a good preparation for lucerne; but they ought to be well dunged, and kept clean of weeds. The seed of lucerne may be sown in drills with a drill-barrow, the drills eighteen inches apart, when nothing is sown with it; or it may be sown broadcast with small grains, and the ground should be well harrowed and rolled. Our practice has been to sow half a bushel of winter rye with the seed to the acre. When it has taken root it withstands the drought better than any other grass, on account of its long tap-roots. It may, and if there are many weeds, it ought to be mown the last of August, after sowing. In subsequent years it may be cut as soon as it shows blossom, and if the soil is good, it will bear cutting three, and often four times in a season. The great economy of this grass is to cut and feed it green. All farm-stock, including hogs, are fond of it. An acre of good lucerne will keep five or six cows from the 20th May to October. If made into hay, it should be cured in cock, to prevent the waste of the leaves. Partially cured, and mixed in the barn with barley-straw, in alternate layers, it saves well, and very much improves the straw. The seed may be had at the seed shops, at twenty-five and thirty cents per pound. It is mostly imported from France.

CHAPTER XVIII.

Root Culture.

Root culture presents many advantages to the stock farmer. Roots are less exhausting to the soil than grain; they are admirably fitted to form a part of a course of crops; are very beneficial in pulverizing the soil; afford abundance of food for farm-stock: may be substituted for grain, and serve to augment and improve the valuable product of the cattle-yard. An acre of ground under good culture will produce, on a fair average, twenty tons of Swedish turnips, mangel wurzel, carrots, parsnips, or potatoes. Supposing a lean animal to consume one bushel a day, and a fattening animal two bushels, the produce of an acre will then subsist three lean bullocks 110 days, nearly the period of our winter, and three fatting ones 55 days. We merely assume these as reasonable data, and ask if the result does not prove the profitableness of their culture. But we are not permitted to doubt upon this subject, if we credit the testimony of those who have tried them, and whose continuance in the culture is the best proof of their value. Roots enter largely into the system of Flemish husbandry, which has been extolled as inferior to none other, and in many parts of Great Britain turnips are considered the basis of profitable farming. In our country, root culture is winning its way to notice and to favour. Few who have managed it judiciously have been willing to relinquish it, while others are annually commencing it. The great obstacles to the more rapid extension of the culture among us is the want of experience, the want of proper implements, as drill-

barrows, cultivators, &c., and the labour of securing the crop in winter. The apparent magnitude of these obstacles is daily diminishing, and we shall, ere long, discover that root crops may be cultivated and secured for winter use, as easily as other farm-crops. We have had very little experience in cultivating carrots, parsnips, or mangel wurzel as field crops; but the Swedish turnip has been a favourite crop for some years; and we can truly say, it has been one of the most sure and profitable that we have taken from our grounds.—*Ed. Cult.*

Ruta Baga, or Swedish Turnip.—The turnip culture is beginning to arrest the attention of our husbandmen, and it will acquire new interest as its advantages come to be better appreciated and its practice better understood. Its introduction into Britain forms one of the most important eras in the improvement of British husbandry, and its introduction into our country will ultimately prove highly beneficial. Of the various species of the turnip, the ruta бага is decidedly superior for the nutritious properties which it possesses, and for its hardy, late-keeping qualities. Having had some years' experience in its culture, we submit the following considerations as the result of our practice.

The *soil* best adapted to the Swedish turnip is one of loose texture and dry, inclining to sand, gravel, or loam. It should be rich, well pulverized, and clean. A clover lay, covered with yard manure previous to its being ploughed under, is to be preferred.

The *preparation* for the crop consists in one perfect ploughing, if a lay, a faithful harrowing, and the roller may be applied between the ploughing and harrowing with benefit.

The *season* for *sowing* is from the 25th June to the 5th July. A cutting of early clover may be first taken off the ground before it is ploughed for ruta бага.

The best *method of sowing* is with the drill-barrow,
VOL. I.—S

an implement which costs ten or twelve dollars, and which comes in use for other purposes, in drills two and a half feet apart. With this a man will put in four or five acres a day. The crop may also be sown broadcast, or drilled in with a line and hoe, though the operation is more tedious, and, when sown broadcast, the expense of cleaning and thinning materially increased.

The *quantity of seed* requisite for the acre is one pound—cost six to eight shillings—though, if well drilled, half this quantity will suffice.

The *after-culture* consists in thinning the plants and keeping the crop free from weeds. The plants should be thinned to eight or ten inches, as soon as they show their second or third pair of leaves, and it is important to have the first weeding performed early, as this not only benefits the crop, but saves subsequent labour.

The *implements* best adapted to the turnip culture are the cultivator, or horse-hoe, and turnip hand-hoe. The first is passed between the drills as soon as the plants show their second pair of leaves, and may be repeated at intervals with little expense and manifest advantage. It destroys the weeds, if applied in time, except on a strip of two or three inches where the plants grow, pulverizes the surface, and renders the soil permeable to atmospheric and solar influence. The operation of cleaning is finished with the hand-hoe, the cutting part of which may be likened to the blade of a thin case knife, the two extremities of which are drawn out, turned up, united, and form the shank to attach the hoe to the handle. The advantages of this hoe are, that it does not gather the dirt and weeds, and may be drawn along the drills as far as the arms extend without being raised, and across the drill, between the plants to be retained, and almost wholly supersedes hand-weeding. Two cleanings with the hoe generally suffice.

Gathering the crop is performed with the greatest economy of labour by drawing the turnips by hand, and laying them separately across the drills, the roots of two adjoining rows towards each other, and then with a heavy knife, billhook, or like implement, strike off the tops with a blow as they lay, which is managed with great expedition. The roots are first gathered and taken to the pit or cellar, and the tops, which are abundant, are then raked into small heaps, and taken to the yard for the farm-stock as they are wanted.

To secure for winter, pits are made in the field, upon dry ground, two and a half feet broad, and as long as may be convenient, and of two to four feet in depth. These are filled, and the roots piled above the surface, in a roof-like form, till they terminate in a ridge. A slight covering of straw is then given, and the whole covered with earth, two feet or more in depth. A salutary precaution is then to make holes, with a bar, at intervals of three or four feet, upon the ridge, through the covering, that the rarefied air which will be generated may escape. This may be partially closed with a wisp of straw. Another precaution is to cover the pits with a coat of yard manure early in December, the better to exclude the frost.

The product, under good management and on a suitable soil, is seldom less than six hundred bushels per acre, and often much more, of roots, besides a heavy burden of tops, of which neat cattle are very fond.

Use.—This turnip is far more nutritious than the common turnip, keeps much longer, and is greedily devoured, cooked or raw, by horses, cows, sheep, and hogs; and is, withal, a very excellent vegetable for the table, particularly from January to June. We are still feeding to cows and oxen (May 23) of the crop of last year. Our cows have eaten them daily for nine weeks, and yet the turnip taste has

not been perceptible either in their milk or butter, *the cows having daily access to salt.* To the sheep husbandman, this root will be found peculiarly serviceable, if fed to his flock in winter and spring, particularly ewes with lamb.

Of all root crops, if we except the common turnip, this is the least exhausting, occupies the ground the shortest time, is cultivated with the least expense, is saved with the least care, and, we think, makes the greatest return in food for animals.

In giving, last year, an account of my first experiment in turnip culture, I mentioned my intention of continuing to raise them, as I was convinced few things could be more profitable. In order to be certain of having first-rate seed, I sent, last winter, to Mr. Buel, at Albany, and procured half a pound of seed, having a quantity of my own raising to make up any deficiency, should there be any. The ground selected was a wheat stubble, was not manured, but thoroughly ploughed, and then thrown into ridges, as described last year. On these ridges the seed was sown by hand, at the distance of ten inches. The seed procured at Albany was sufficient for the whole acre, and a small quantity was left. The time occupied in sowing was about a day and a half. I sowed them a few days earlier than last year, viz., on the 16th of June, as they appeared last year to be in full vigour at the time of pulling. I gathered them the first week in November, and, from the acre sown with the Albany seed, measured 450 bushels of very fine, smooth turnips. Nearly one fourth of the ground sown was inclining to clay, and in some places produced no turnips; thus furnishing another proof of the correctness of Judge Buel's remark, that clay ground is unsuited for a turnip crop. Owing to an unusual pressure of farming business, my turnips were hoed but once, which was at the time of thinning, the

first week in August. My account with ruta бага, for the year 1834, will stand as follows :

Ploughing twice, and ridging	\$3 00
Seed	75
Six days work, thinning and hoeing	4 50
	\$8 25

The tops will pay for the use of the land and the gathering. Four hundred and fifty bushels of turnips, at twenty cents per bushel, would be ninety dollars, leaving a profit of something like eighty dollars.

There is an impression among some people that capital employed in farming is but poorly invested. It may, in some cases, be so ; but such is not the result necessarily. The land on which my turnips were this year raised was part of a small field of four acres, which had been a meadow for several years, but the grass becoming thin and poor, it was, after the mowing in 1830, turned carefully over, dragged on the furrow with a light drag, and sown with wheat. After the wheat was taken off, a quantity of manure was, in the fall of 1831, put on the stubble, and the whole ploughed in. In the spring of 1832 it was again ploughed and sown with barley. The barley stubble was ploughed in, and the field again sown with wheat. In the spring of the present year the wheat stubble was turned in, and the piece rolled down smooth, and three acres planted with corn. As the ground had been carefully levelled, the corn was planted in rows two feet and a half apart, and the hills eighteen inches from each other in the rows ; at the first hoeing three stalks were left in a hill. It was hoed twice, the principal part done with a cultivator, and the corn was hilled as little as possible. At gathering, it was estimated to yield from sixty-five to seventy bushels an acre ; and one acre was sowed with the

turnips. The avails of these four acres, for the four years, will be as follows :

1st crop,	100 bushels	wheat, 8s.	. \$100 00
2d "	120 "	barley, 4s.	. 60 00
3d "	90 "	wheat, 8s.	. 90 00
4th " —	{ 190	corn, 4s.	. 97 50
	{ 450	turnips, 20 cts.	. 90 00
			\$437 50

No account of the expense of culture was kept, except for the last two years ; and as it will be seen at a glance that it was performed in the simplest manner possible, on comparing it with recorded results, I am confident that thirty per cent. would be a liberal allowance for seed, labour, &c., leaving a profit on the four acres, for the four years, of about three hundred dollars.

It has been frequently remarked, that small farms were more profitable than large farms. This is, no doubt, in most cases true ; and it is easily accounted for by the fact, that on well-cultivated small farms much more capital is employed on the land in the shape of labour, manure, &c., than upon large farms. A small farm bears the same relation to a large farm in this respect, that the garden of the small farm does to the remainder. Where the soil is naturally equally good throughout the whole farm, let it be small or large, it might be made as productive and profitable as the garden, were the same capital employed upon it. In farming, as in most other kinds of business, it is idle to expect something for nothing ; the returns in nine cases out of ten will be in proportion to the labour bestowed.—*Willis Gaylord.*

Mangel Wurzel.—John Schmoldt has published in the *Farmer and Gardener* some facts in regard to this crop, which possess interest to those who cultivate and use it as cattle food. He states :

1. That plucking the leaves, as has been often

recommended, for cattle food, before the crop has attained maturity, is, always prejudicial to the growth of the roots. Here experiments have confirmed what reason would dictate, that nature furnishes no more leaves than what are necessary for the plant. A square rod where the leaves had been plucked gave 117 1-2 lbs. roots; and an adjoining square rod on which the leaves had been left gave 157 lbs. Other experiments gave similar results.

2. That a greater product is afforded when the plants are two feet apart than when they are one foot.

That at 1 foot each way a square rod gave 192 lbs.

That at 1½ feet each way a square rod gave 235 lbs.

That at 2 feet each way a square rod gave 305 lbs.

This is owing to the roots growing larger at the greater distance. Here Chaptal's remark occurs to us, that small beet-roots contain double the per cent. of sugar, and, consequently, of nutritious matter, that very large roots do. And this reminds us, too, of a very dissimilar fact in regard to ruta бага, viz., that the larger the roots of these the more they abound in nutriment.

3. That it is difficult to preserve the roots during the winter. A little frost destroys them, and if in large masses, or in a damp or warm situation, they are subject to grow or to spoil.

4. That 45 lbs. mangel wurzel roots are equivalent in nourishing properties to 10 lbs. hay, and that, consequently, it is necessary to give daily 100 to 150 lbs. to fatten a bullock. The ruta бага, mangel wurzel, and potato yield about the like nutriment to cattle. We have fed oxen two bushels a day of the former, each for three months, with a little hay, and had them fatten well; and some Scotch feeders have gone as high as four bushels a day to a fattening ox.

5. That the mangel wurzel is liable to produce a surfeit, and to impair the digestive organs if given

in two great quantities, or continued for a long time. Hence hay, or straw, or other roots should be given with them.

The foregoing facts are not given to discourage the culture, but to remove error.

Yield of Carrots.—Mr. Wilson, of the Albany Nursery, sowed a piece of ground 111 feet in length, and 39 broad, with carrots, in drills 18 inches apart. The product was 6321 pounds, topped and freed from dirt. This is at the rate of about 31 tons, or 1030 bushels, of 60 pounds each bushel, per acre. The ground was first trench ploughed, then well dunged, and ploughed again; unleached ashes were then spread upon the ground at the rate of fifty bushels the acre, the ground well harrowed, and the seed sown. The plants were thinned to six inches. Mr. Wilson thinks it would increase the crop to sow in drills at two feet, and that in this case the crop might be cleaned principally with the cultivator, particularly with Van Bergen's.

Carrots are fine food for all farm-stock, and are particularly beneficial to horses, and are considered to be worth, for this purpose, as much per bushel as oats. At three shillings per bushel, a thousand bushels would be worth \$375 00. They are worth at least half this for any kind of farm-stock, which would still make them a *very* profitable crop.

CHAPTER XIX.

Madder—Hops.

Madder (Rubia Tinctorum).—This plant has a perennial root and an annual stalk. It is cultivated for the roots, which, after being dried and ground, are employed in considerable quantities in dyeing a fine red colour, and, likewise, as a first tint for several other shades. It is principally cultivated in Holland, the province of Zealand being almost entirely covered with it; from whence it is exported to every part of Europe and America, yielding almost incalculable profits. The imports of this article for the use of our manufactories is stated to amount in value to more than two millions of dollars annually. Our soil and climate are found to be well adapted to its culture, and some successful experiments have been made in raising it in the counties of Madison and Otsego.

Madder does best in a deep rich sand-loam, moist but not wet. It requires three summers to come to perfection; and as the roots strike deep, the ground should be ploughed and mellowed to the depth of two and a half or three feet for its reception. Miller says it should be planted with a dibble (it is propagated by offsets from the roots), in rows from two to three feet apart; while Beechstein says they should be planted only six inches asunder. The practice in this country, we believe, for we are not personally acquainted with it, is to plant in rows four to five feet apart, and to cultivate rows of corn or potatoes between them, at least the first year. The season for planting is in May or June. The acre produces from ten to fifteen and twenty hun

dred weight. The price in the market is about twenty cents per pound.

Cultivation of Madder.—I began the cultivation in the spring of 1831. I planted the top roots, or seed, in hills four feet apart each way, two hundred and fifty hills, or about one ninth of an acre; kept it free at all times of weeds, and for two seasons continued to throw earth on the tops, thereby increasing the quantity of top-roots, and promoting the growth of the bottom. I dug the madder last fall, washed and air-dried them two or three days, and afterward perfectly in a kiln; ground them in a gristmill, and weighed them; the result was 135 pounds; and I believe the top-roots, or seed, if I had dried and ground them, would have weighed about fifty pounds: making 185 pounds, at nineteen cents, would amount to \$35 15, or \$316 per acre; but as I sold the top roots for seed, they brought me a far greater sum. In 1832, I planted 600 hills in one piece of ground, same distance as before; this will be dug the ensuing fall, and the seed forwarded to Albany if any person should request me to do so. The price here in September and October will, probably, be about \$3 per bushel by the quantity.

In 1833 I planted eight acres in drills, scant six feet in the rows and one foot in the drills; and should, if the ground had been free from that terrible scourge quack grass, have planted forty-eight bushels. I hired this piece of ground just after a harvest of wheat, and was ignorant that it was covered with quack in the room of wheat: this circumstance in the following spring compelled me to plant seventy bushels in room of forty-eight. The whole expense in cultivating this crop should not have exceeded \$800 for four years; but, in consequence, it will probably cost \$1000. The profits of other crops between the rows of madder to be deducted from the expense, the amount of the crop, when fitted for market, four years' cultivation, a

clean and rich piece of land, calculating madder at one shilling, would be \$2000. I planted this piece of ground about the last of April or first of May; and about the first of June, after I had cleaned the drills of weeds, I planted between them, alternately, corn and potatoes. I had 1070 bushels of pink-eye potatoes, sixty bushels of corn; the corn, being eleven or twelve feet apart, did not do very well, and the worms were very plenty; the potatoes were, perhaps, better for being planted at so great a distance. I consider the quantity of ground planted with potatoes and corn each about two and a quarter acres. The ground for the potatoes was furrowed, and the potatoes covered with the plough, and hoed once. I made in this piece some experiments in the cultivation of potatoes which I shall be glad to communicate to the public through the columns of the Cultivator. 1834, this spring planted potatoes between every other drill of madder; after having weeded and covered the madder-tops once, the crop may be about 6 or 700 bushels. I believe the price of good Dutch madder for twelve years past has averaged about fifteen cents through the year, and eighteen cents in the fall in the New-York market. The madder of this country is worth three or four cents more; at any rate, I have not known any sold at wholesale to merchants in the country short of twenty-three cents. The cost of raising this article is about seven cents per pound; that is, the whole expense of cultivating, washing, drying, grinding, &c., including a fair rent for land. The least quantity I have seen dug from an acre is 1600 pounds, and greatest 2400 pounds, four years. If I had first-rate land, and price of madder good, I should dig third year. Mr. Jefferson, in one of his letters from France, says, "They cultivate madder here at an immense profit; they dig it once in five or six years." I estimated that in planting the nine acres I should furnish a supply for the county of

Oneida, since which time a calico manufacturer of Otsego county has informed me that he uses 100 pounds of madder per week through the year, which is more than I raise. I will now give you my reasons for thinking that it is not an impoverishing crop: the 250 hills that I planted first was on a hemlock soil of ordinary strength, and at the depth of fifteen inches was a brown dead sand, hard-pan, if I may so express it; and as the madder roots penetrate two feet or more, they could not have done so well as on a rich deep soil; still I had over 1600 pounds. I have on the same ground an uncommon heavy crop of oats, and no manure has been put on it for six years past.

Hop Culture.—The soil most favourable to the growth of hops is a deep rich loam, pretty strongly inclining to clay, moist, but not wet; and the sub-soil should be porous, so as not to retain the water which settles from the surface. The largest crops are grown in Britain upon a kind of slaty ground, where the under stratum is rock. The most desirable situation for a hop plantation is ground sloping gently towards the south and southwest, and screened by means of high grounds or forest-trees from the north and northwest. At the same time it should not be confined so as to prevent the free circulation of air, which is indispensably necessary to the well-being of the hops; as not only conducing to the health and vigour of the plants, but as tending to prevent blight and mildew. The neighbourhood of fenny or swampy grounds is unfavourable to the hop crop.

In preparing the soil previous to planting, considerable attention is necessary, by fallowing or otherwise, to destroy the weeds, and to reduce the soil to as pulverized a state as possible. The ploughing should be deep, the ridges made level, and the dung applied with a liberal hand.

The mode of planting is in rows, with intervals,

generally, of six or eight feet. A good way is, after the ground is prepared, to draw furrows both ways across the field, at the intended distance of the hills, and to plant at the points of intersection. At eight feet apart there will be 680 hills on an acre; at six feet, 1210. Planted in this way, the ground may be kept clean, and worked by the harrow and cultivator.

The time of planting is, generally, in the spring, when the old plants are dressed and pruned, and from which cuttings and sets may be obtained. Plantations may also be made in October and November. Sometimes roots and sets are planted one year in the garden, to give them strength and vigour, and then removed to the plantation.

The plants of cuttings should each have two joints or eyes; from the one which is placed in the ground springs the root, and from the other the stalk, provincially the bind. They should be made from the most healthy and strong binds, being cut, generally, to the length of five or six inches. When the ground has been marked out, take out a spit or spade depth of earth where the furrows cross; loosen the earth below, and throw in half a bushel of fermented dung, or compost, or surface mould, into each hole; then replace so much of the earth taken out as to form a small hillock. Upon this put in with a dibble five or six sets, at intervals of six inches, inclining to the centre, where one of the plants may be placed.

An interval crop is generally taken the first summer of beans, potatoes, or even corn, though the smaller the system of roots of the internal crop the better. It should be a hoed crop, in order that the ground be kept clean. The hops do not produce anything the first year. The common cultivator may be used in cleaning the interval crop; the hop-hills may be slightly earthed, and weeds destroyed.

The process of tilling, hoeing, and earthing up, is an
VOL. I.—T

annual operation performed in the spring, and manure is applied once in three years. It is either laid on the hills of the hops or in the rows, and buried with a shallow furrow. In June the operation of twisting is performed on such plants planted in the spring as are not expected to produce any crop that season, and consists in twisting the young vines into a bunch or knot, so as to induce a more vigorous growth of roots.

The yearly dressing of established hop plantations consists of what is provincially called picking. This operation is generally commenced, as early as the season and soil will permit, in April, when the hills are spread out, in order to give opportunity to prune and dress the stalks. The earth being then cleared away from the principal roots by an iron instrument called a picker, resembling a dungfork, but with more and lighter teeth; the remains of the former year's vines are cut off, together with the shoots which were not allowed to attach themselves to the poles the former season, and also any young suckers that may have sprung up about the edges of the hills; so that nothing is allowed to remain that is likely to injure the principal roots or impede their shooting out strong vigorous vines at the proper season. After the roots are properly cleaned and pruned, the hills are again formed, with the addition of the manure when applied.

Poling the hop is performed in April, when the shoots have risen to two or three inches. The poles may be twelve to fifteen feet in length, and sufficiently stout to resist the strength of the wind when covered with the hop-vines. They are fixed in the ground by making deep holes with an iron crow, and ramming the earth well round them after they are inserted in the holes. Two, three, or four poles are placed at each hill, in such position as to leave the south side open to the meridian sun.

Tying the vines to the poles is an important opera-

tion. It is performed as soon as the vines have grown sufficiently to require it, and repeated till they have attained a secure height. Two or three strong vines are selected for each pole, wound round, and tied loosely with withered rushes, bass matting, or other ligature. The remaining vines are then cut away.

Picking the crop is thus performed: frames of wood are raised in the most convenient part of the plantation. These frames consist of four boards nailed to four upright posts, the whole frame being about eight feet long, three feet wide, and three feet high. Six, seven, or eight pickers, generally women or boys, are placed at the frame, three or four being at each side. The plants being cut through at the root, the poles are lifted up and laid upon the frame, with the hops upon them. The pickers then can freely pick off the hops, which they drop upon a large cloth which is hung upon the frame with tenter-hooks. When this cloth is full the hops are emptied into a large sack and carried to the drying-house, where they are kilndried and bagged for market. The hop crop should be gathered *when it is ripe*, and before the autumnal frosts. For the criteria of ripeness, or the period when they are best fitted to gather, and directions for drying, we refer to the brewers' circular, at page 83 of the second volume of the Cultivator.

The process of packing is thus managed: in the floor of the room is a round hole equal to the size of the mouth of the bag. The mouth of the bag is then fixed firmly to a strong hoop, which is made to rest on the edge of the hole. The bag is then let through the hole, suspended by the hoop, and the packer goes into it. Another person puts the hops into the bag in small quantities at a time, and the picker tramples them firmly down. When the bag is full it is drawn up, and the end is sewed. The hops are now ready for market. In the mean time

the poles in the plantation have been stripped of the stems attached to them, and set up in stacks to await the following year. A hop plantation lasts from ten to fifteen years, when it must be renewed, the old roots dug up, and fresh sets planted on another plat of ground.

The produce of the hop is variable. It varies from two to twenty hundred weight the acre; 1200 is, perhaps, about the medium. We have no data as to the cost of labour; but, assuming the above medium, and that the average price is twenty cents per pound, the produce of an acre will be worth \$240, the expenses to be deducted.

CHAPTER XX.

Ploughing.

[THE most common operations in husbandry are frequently the worst performed. Accustomed to them from boyhood, we acquire the habit of doing them mechanically, without scanning well their object, or investigating the principles upon which they ought to be conducted. Our ploughmen would think themselves insulted if told they did not know how to plough their grounds well. And yet, without intending to charge them with this defect of knowledge, we are free to say we do not find hardly two fields in fifty *ploughed well*. There are three principal objects that should be aimed at in ploughing: 1. To break up the *whole* surface of the field; 2. To give the *greatest exposure* of fresh earth to the atmosphere; and, 3. To induce the greatest pulverization of soil. It is too much the practice to *cut and cover*, and to lay the furrow-slice flat, which neither gives the greatest exposure nor induces the

best pulverization. We are persuaded, that what we are about to offer upon this subject may be read with advantage by even the best ploughmen, however trite and well understood the subject may appear. The principle illustrated in figure 6 is particularly important.]

The Plough.—By means of this instrument the earth is to be turned over to a given depth: and this is to be effected by cutting from the ground successive sods or slices of earth, so that each sod or slice shall be raised up and turned over, and all the sods or slices laid resting upon each other, in such a manner as that an entire new surface shall be exposed to the atmosphere.

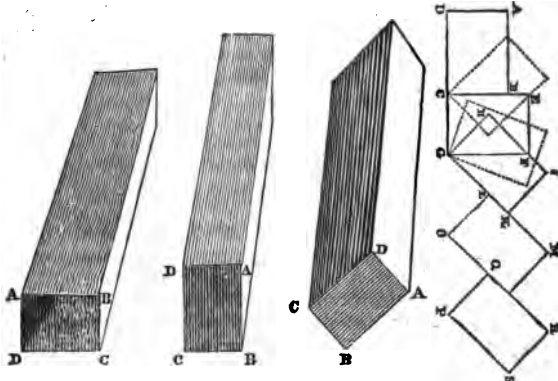
In the following figures, let A B C D represent the end or transverse section of the slice of earth which is to be turned over.

Fig. 1.

Fig. 2.

Fig. 3.

Fig. 4.



The slice is first to be raised from the position in which it lies in fig. 1: it is next to be placed in the

position shown in fig. 2: and it is finally to be placed in that represented in fig. 3.

In the diagram, fig. 4, let A B C D, corresponding with the same letters in figs. 1, 2, 3, represent a transverse section of the slice of earth which is to be turned over. This slice is first to be raised from its horizontal position A B C D, by being turned upon its corner C as a pivot, and placed in the position C E F G, corresponding with that of fig. 2. It is then to be turned upon its corner G as on a pivot, and laid in the position G H I K, corresponding with that of fig. 3. In this manner, the side D C, which was formerly underneath, will be above, namely, in the position H I; and if successive slices shall be thus reversed, they will rest upon each other in the manner shown by the sections of the slices P Q R S, O L M N, and G H I K.

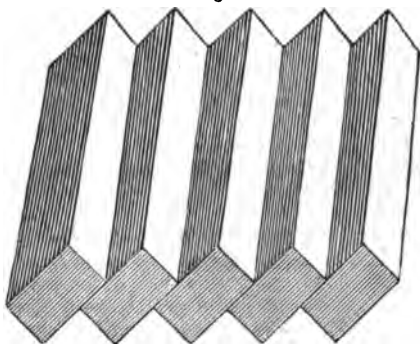
The angle of inclination at which these different slices will naturally rest upon each other in the manner shown in the figure, will depend upon the proportion which the width of the slices bears to their depth; and that the greatest extent of surface may be exposed to the air, the angle of their inclination will be 45° . In order, therefore, that the slices may be at this angle, the proportion which the width of the slices bears to their depth is to be determined; and this can be done by simple calculation; for it can be shown that the width of the slice A B, being the hypotenuse of an isosceles right-angle triangle, the depth of the slice B C will be one of the sides. Supposing, therefore, the width of the sod A B to be ten inches, the depth B C will, by calculation, be 7.071 inches.

If, then, beginning at one side of a field, we shall cut off a slice of earth the entire length of this field, and place in the position P Q R S, fig. 4, and then cut off a second slice, and place it in the position O L M N, and then a third slice, and place it in the position G H I K, and so on, the various slices will

rest upon each other at a given angle, in the manner represented.

A similar operation is to be performed by the plough. Beginning at the right-hand side of the field or ridge to be ploughed, a sod, which we shall now call a furrow-slice, is to be cut from the firm ground, raised up, and turned over. A second furrow-slice is in like manner to be cut from the firm ground, raised up, and turned over, and so on. In this manner, an entire new surface will be exposed to the atmosphere, and the successive furrow-slices laid resting upon each other, thus :

Fig. 5.



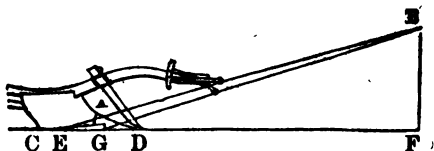
An essential property of the plough is that it shall move in the earth with a steady motion; and the giving to it the form and combination of parts necessary for that purpose, is one of the main difficulties attending its construction.

Were it ascertained by experiment on the plough when at work, at a given depth of furrow, and in soil of a given texture, that a cord attached to any point A, fig. 6, and drawn in the oblique direction A B, would so pull forward the plough that it

should press uniformly upon the earth at all points from C to D, so that the share should neither tend to point upward nor downward, but should move horizontally forward, then it is to some part of this line that the moving power should be applied; and farther, it is known from the principles of mechanics, that it matters not, in so far as regards the force exerted, to what precise part of this line the power is applied. Now, without entering into any mathematical investigation of the principles upon which this line is to be determined, it is to be observed, that in a well-made plough, formed on the principles pointed out, this line, drawn from the usual point of attachment of the draught on the collars of the working cattle, will intersect the sole of the plough at E, a little behind the setting on of the share, and a little to the right of the plane of the left side of the instrument.

Now, knowing the height at which the point of draught is to be attached to the shoulders of the working cattle, let us suppose 4 feet, and the distance from the point of the share at which the animals of draught can be conveniently yoked, let us suppose 12 feet, then laying off D F 12 feet, and

Fig. 6.



FB 4 feet, and drawing B E, it follows that the point at the end of the beam, to which the draught is attached, may be placed in any part of the line B E. So that, whatever be the length which we shall give to the beam, the line in question will denote the end of it, or the point to which the draught is to be attached.

But the angle which the line E B forms with the surface is not, as can be shown, constant, but varies with the depth ploughed and the tenacity of the soil. That the instrument may suit itself to these variations, as well as that any defects in the form of its parts may be counteracted, and that the line of draught may be placed in that position which is required to pull forward the plough, without there being any tendency in the share to sink into the ground or rise out of it, the bridle is fixed at the end of the beam, so as to elevate or depress the line of draught as may be required. Should the plough, for example, tend to go deeper into the earth, the line of draught is to be lowered by means of the bridle, so that it shall form a greater angle B G F; the effect of which will be to counteract the tendency which the plough has to go deeper. The same effect will be produced by shortening the traces by which the horses are attached to the draught, and thus increasing the angle. In like manner, by means of the bridle, the point of draught can be shifted to the right or to the left. If the point of the share tends to turn to the left hand into the firm ground, the line of draught is shifted more to the left, and if to the right hand, it is shifted more to the right. This adjusting of the plough's motion is easy, and is performed by the ploughman, until he feels that the plough continues to *swim fair*, to use his own technical language; that is, until he feels, which he does at once, that it continues to move horizontally forward, without any tendency to turn to the right or left, or to rise from the earth or to sink into it. A well-constructed plough of this kind, therefore, needs no wheels or other devices to steady its motion; the effect being produced by merely altering the direction of the line of draught.

In ploughing, it has been seen, a slice of earth is to be cut from the left-hand side and to be turned over to the right-hand side. In this operation, the

left-hand or near-side horse walks on the ground not yet ploughed, the right-hand or off-side horse walks in the furrow last made, and the workman follows, holding the handles of the plough. By means of these handles he guides the plough, and he directs the animals of draught by the voice and the reins. When he is to turn the plough at the end of a ridge, or when it encounters an obstacle, as a large stone, he presses down the handles, so that the heel of the plough becomes a fulcrum, and the share is raised out of the ground.

In ploughing, the instrument ought to be held vertical. If it is inclined to the left-hand side, the same work is performed in appearance, though not in reality ; a portion of the ground below not being tilled at all, but left thus :

Fig. 1.



The plough is of the most perfect form when its various parts are so adjusted that they shall not oppose each other's motion : but it is very difficult to form a plough that is perfect in the form and combination of its parts. Even in those of the best construction, there is frequently found to be a tendency to rise out of the ground or to turn to one side, generally the right-hand or open side. The tendency to rise out of the ground can be corrected by giving an inclination downward to the point of the share ; and the tendency to turn to the open or right-hand side can be corrected by turning the point of the share slightly to the left-hand side. By these means, however, the labour of draught is increased, and care must therefore be taken that this tempering of the irons, as it is frequently called, be not in any case carried farther than is necessary to correct the defects of the instrument. All that is necessary beyond this is effected by changing the position of the line of draught by means of the bridle on the beam.

With regard to the depth to be ploughed, this, we shall see in the sequel, depends upon the kind of crop to be cultivated, and other circumstances. It has been shown that a furrow-slice of ten inches in width requires a depth of seven inches: that is, a depth of about two thirds of the width, in order that it may lie at an angle of 45° . But although it is necessary to proceed upon this principle in forming a plough, we cannot regulate the depth to the width in this manner in practice. It is not necessary that the depth should be to the width in the proportion of two to three, or that the sod should lie precisely at the angle of 45° . In the field all that can be arrived at is a kind of approximation to the true proportions. When the sods are considerably too wide in proportion to their depth, the ploughman will be admonished of this by their lying too flat, and too slightly overlapping each other. When their depth is considerably too great in proportion to their width, they will stand too upright, and be apt to fall back again into the furrow.

The medium depth of good ploughing may be held to be seven inches. When circumstances, as the kind of crop and the nature of the soil, do not require deep ploughing, the depth may be less: but it will be considerably more in those cases to be afterward adverted to, where deep ploughing is from any cause expedient.

In the moist climate of this country, and indeed in most others of Europe, it is necessary to form the ground into what are termed ridges, so as to admit of the water which falls upon the surface finding a ready egress. And even in lands so dry that little injury will result from stagnating water, such ridges are generally formed on account of their convenience in the different works of tillage.

The first operation in the forming of ridges is *striking the furrows*.

Let it be supposed that a field has been laid level

by previous ploughings, and that the marks of former ridges being obliterated, the lines of the new ones are to be laid out. The usual breadth of ridges is from 15 to 18 feet, and sometimes more. We may assume, in the following descriptions, 15 feet to be the width of the ridges.

Let a steady ploughman be furnished with three or more poles of wood, shod with iron, eight or nine feet in length, and divided into feet and half feet. The first operation is to mark off at two sides of the field what is termed a headland. This is merely a ridge formed parallel to the side of the field on which the horses are to turn, to afford sufficient space for which, the ridges must be 18 feet wide. The lines of them are marked off before the ridges, in order that the ploughman may know, on arriving at the end of the ridge, when to turn his horses. After the rest of the field is ploughed, the headlands themselves are ploughed and formed into ridges.

In the following diagram, representing a field, let E F, G H, represent the lines of the headlands, drawn parallel to A B and C D, the sides or boundaries of the field, and at the distance from each of these sides of 18 feet. These lines the ploughman marks out by running a straight furrow with his plough parallel to the two sides.

Let him now, beginning at the side of the field A D, parallel to which it is intended to run the ridges, measure off with his pole E a, 7 1-2 feet. At the point a let him place one of his poles. This is the point at which he is to *enter* his plough. But, leaving his horses in the mean time, let him walk on to a convenient distance, as to I, and there, in like manner measuring off 1 b, 7 1-2 feet, let him set up his second pole at b, and then, at the farther end of the field, on the line of the headland, at c, let him place his third pole. He has now three poles placed in a line; but if, from the length of the field or inequali-

ties of the surface, more than three poles are necessary, more must be used, as there must be so many poles in sight as that the ploughman may be enabled to direct his plough, by means of them, in a straight line. He now returns to his plough and enters it at the first pole, at *a*, keeping the other two poles in a line, so that he may be enabled to plough directly towards them. Having entered his plough at *a*, he stops his horses and measures off 15 feet to *d*, where he plants the pole. He then returns to his plough, which is standing at *a*, and drives his horses, keeping the two poles before him as a guide, to the second pole *b*. Having done this, and leaving his plough standing at *b*, he measures off from *b* to *e*, 15 feet, and there he plants his pole. He then returns to his plough, and proceeds forward, making his furrow in a straight line to the last pole *c*, where in like manner he stops his horses, and, measuring off 15 feet, he plants his pole at *f*.

In this manner he has placed his poles in a straight line, at the distance of 15 feet from their last position, and parallel, as before, to the line of fence. He now turns his horses sharp about, and returns by the furrow which he has just drawn, *c b a*. By this second ploughing he throws the earth out in an opposite direction, so that he has formed a completely open furrow. In returning, he takes care to correct any inequality or crookedness that may have taken place through the unsteady motion of the horses in his first track.

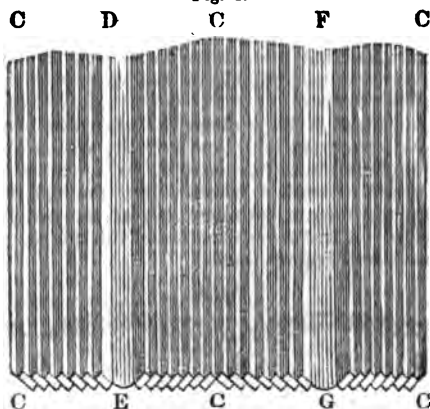
The poles being now placed in a line, *d e f*, he brings his plough to *d*, enters it, and stops it there. He measures off 15 feet with his pole, from *d* to *g*, and fixes his pole at *g*; and then he proceeds with his plough to *e* and *f*, repeating the same operation with his poles as before, and returning by the track of his last-made furrow from *f* to *d*. In this manner he proceeds throughout the whole field, forming parallel open furrows, at the distance from each other

crown or centre, and H E and o s the termination. By proceeding in this manner throughout the field, the whole is formed into ridges, of which the first marked furrows are the centres.

It has been said that the ploughman continues turning his horses to the right, and that thus, after having proceeded from *a* to *c*, he returns from *c* to *a*, and so on, always ploughing round *a c* as a central line. When, however, he has proceeded from *a* to *c*, he may turn his horses left about, and return from *f* to *d*, and so on, always laying his furrow-slices towards *a c* and *f d* respectively. In this manner he will have ploughed the half of two adjoining ridges, and terminated at the space *o s*, half way between them. This method of ploughing, it will appear, has the same effect as turning the horses right about, and is the most frequent and convenient in practice.

In the following figure, in which C C, C C, C C, are the centres of the ridges, the manner in which the successive furrow-slices have been laid upon each other is shown.

Fig. 3.



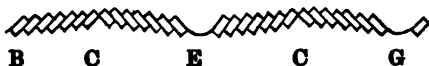
By this laying of the earth towards the centres, the ridges acquire a certain curvature. By ploughing the earth away from the intervals D E, F G, the ground is hollowed at these parts, which now form the *open furrows*. It is by these open furrows that the water which falls upon the surface finds a passage.

A certain though not a great degree of curvature, is given to the ridge by this ploughing. It is frequently, however, necessary to give it a yet greater degree of curvature and elevation. This is done by ploughing the whole ridge a second time and in a similar manner.

The plough is first driven along the centre of the ridge from C to C, forming an open furrow. Successive furrow-slices are then laid towards this furrow, in the same manner as in the previous ploughing. This is done with the successive furrow-slices, until the plough reaches the open furrows, D E, F G. In this manner the whole ridge is ploughed, and an increased elevation and curvature given to it. The operation is termed *gathering*.

In performing the operation of gathering, it is important that the ridge be formed with a uniform curvature, so that it shall not have what is technically termed a shoulder, or hollow part on each side of the crown. It is to prevent this defect that the open track is made along the crown before the first two slices are laid together; by which means the ploughman is better enabled to lay them upon each other in such a manner that they shall not overlap and form a protuberance at the crown of the ridge. A transverse section of the ridges, when gathered, will appear thus :

Fig. 4.



A ridge, however, being already formed, it may be wished to plough it again, and yet to preserve it at the same curvature and elevation. In this case, the plough is to enter at the open furrow, and to lay the successive furrow-slices towards it, until the two adjoining ridges are ploughed. By this means all the slices of the same ridge lie in the same direction, and the curvature and elevation of the whole remain as before. This operation is termed *casting*, and the manner in which the furrow-slices rest upon each other will appear in the following figure :

Fig. 5.



In the operation of casting, two methods may be pursued. The first two furrow-slices, as those at E, &c., may be laid resting upon each other as in the figure above, in which case the two ridges will be formed, as it were, into one large ridge ; or else the open furrow at E may be preserved by keeping the two first furrow-slices at a little distance from each other, and preserving the space between them thus :

Fig. 6.



When land is ploughed in this manner, the ground is taken from one side of each two adjoining ridges at G, and laid towards the other E, that is, it is gathered towards one side and gathered from the other. In this manner the ground at the open furrows G, from which we gather, becomes more bare of earth than the open furrow E, towards which we gather. This is an imperfection unavoidable in casting a ridge. When, therefore, we wish to cast a ridge twice in succession, we reverse the former mode of

ploughing ; we gather towards the open furrow G and from the open furrow E, and thus the ridge is restored to its former state.

Another method of ploughing is *cleaving*. In this case, the plough commences at the open furrow, lays the first slice towards it, and then, returning, by the other side of the open furrow, lays the second slice upon the first, as in the following figure :

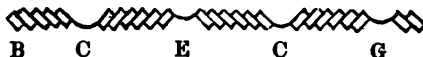
Fig. 7.



When it has reached the centre, it stops and begins with another pair of ridges, and ploughs the half of each pair together in the same manner. In this way the open furrows of the ridges become the centres, and the former centres become the open furrows. The operation of cleaving is of constant occurrence in the summer fallow and other cleaning processes of tillage. When we wish to level a ridge, we cleave it.

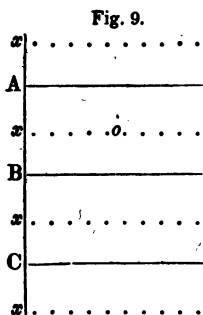
There are two variations to be noted in the practice of cleaving. Either the first two slices are laid close together, in which case the open furrows of the former ridges become the centres, and the former centres the open furrows, in the manner shown in the last figure ; or a certain distance is kept between the first two slices, and so the open furrow is preserved. In this case each ridge is split into two ridges, and the number of open furrows is doubled, thus :

Fig. 8.



The next method of ploughing is *cross-ploughing*. This, as the name denotes, is ploughing in a direction crossing that of the former ridges and furrows.

In cross-ploughing, the workmen place themselves at equal distances from each other, as thirty or forty yards, at the side of the field at which they are to begin to plough. Each then runs a straight furrow



across the field, as from A to D, from B to E, from C to F. Each then returns as from D to A, from E to B, D from F to C, laying always the successive furrow-slices towards the right hand, until each man arrives at the termination of his allotted space *xx, xx, xx, xx*. There has been thus formed by each workman one great ridge, F but so extended that it may be said to be without curvature. The ploughmen, we

perceive, turn from left to right around the first furrows A D, B E, C F. But they may also turn from right to left. Thus, in going from B to E, the ploughman lays his first furrow-slice to the right hand. When he arrives at E, he may turn his horses left about, and proceed to D, and returning from D to A, lay his first furrow-slice to the right hand towards D A. Turning left about then at A, he proceeds in the direction B E, and so on, always turning left about until he has arrived at the middle space *o*, when the whole space between A D and B E will have been ploughed.

Sometimes, for convenience and the saving of distance, he may plough in the first place round the central line B E, by turning from left to right, and then plough the remainder of the interval by turning from right to left.

These are matters of detail somewhat difficult, perhaps, to be described clearly, but so simple in themselves that they need only be seen in the field to be thoroughly understood.

The first operation, we have seen, is striking the furrows previous to forming the ridges. This is done by laying off, by means of furrows, first the lines of the headlands, and then the parallel lines corresponding to the future centres of the ridges to be formed.

The next operation is forming the ridges. This is done by beginning at the centre, and ploughing towards it till each ridge is formed.

When ridges are formed, they may be subsequently ploughed in different ways.

First. They may be gathered; in which case, beginning at the crown, the ridge is ploughed, and an increased elevation given to it.

Second. They may be cast; in which case two ridges are ploughed together, and either formed into one large ridge, or, by keeping the open furrows clear, retained in two ridges.

Third. They may be cloven; in which case, beginning at the open furrows, the half of each adjoining ridge is laid together. The first two furrow-slices may either be laid close together, or the open furrow may be kept clear between them. In the first case, each ridge will have been so cloven as that the open furrow shall have become the crown, and the crown the open furrow. In the second case, each ridge will have been cloven into two, and the number of ridges and open furrows doubled.

In the original laying out of the ridges, the lines have been described as running straight through the field; but it is frequently expedient, on account of the inequalities of the surface or other cause, to change the direction of the ridges at some part of the field, so as to facilitate the discharge of the water.

The application to this case of the principle of striking the furrows is easy. The ploughman makes a furrow where the change of direction is to take place, straight or curved, as circumstances may re-

quire. The one set of ridges terminate at this part, and the other are laid off from it in the new direction to be given. The ploughman, by means of his poles, as before, strikes his first set of furrows, terminating them at the furrow where the change of direction is to take place. From this furrow he strikes his second set of furrows, in the direction in which they are to run. The part where the opposite sets of furrows meet may be made an open furrow, or a raised-up ridge or headland, as circumstances may require.

The direction of ridges must generally be regulated by the sloping of the fields, and the lying of ditches or fences, so that they may promote the main purpose for which they are formed, the carrying off of surface water. But, other circumstances being alike, they should be made to lie as much as possible north and south, and as rarely as possible east and west; for, in the latter case, when the ridges are much elevated, the north side has a somewhat less favourable exposure than the south side.

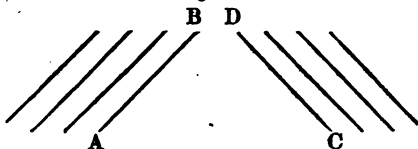
Sometimes ridges are altogether dispensed with, either when the land is very dry, or when it is wished to keep it in grass, and give it the aspect of a park or lawn. In this case, the ploughs may either follow each other round the entire field, and terminate at the centre, or they may plough in large divisions, as in the case of cross-ploughing.

In ploughing very steep land, it is frequently laid in ridges diagonally across the slope, for the purpose of rendering the labour more easy, and of lessening the danger of torrents carrying away the surface.

The precaution to be observed in this case is to make the ridges slope upward from the right hand, as from A to B, in the following figure, and not to the left hand, as from C to D. For, in the first case, when the labouring cattle are ascending the

steep, the plough is throwing the furrow-slice down hill; whereas, in the other case, when the cattle are ascending, they are raising the furrow-slice up hill, by which their labour is greatly increased.

Fig. 10.



Besides the open furrows of the ridges, which act as channels for carrying off the water, it is necessary, where there are hollow places where water may stagnate, to form open furrows or channels. This is done by drawing a furrow with the plough in the direction most convenient for the purpose. A workman then follows with the spade or shovel, and carefully opens all intersections with other furrows, so that there may be a free communication between them.

Sometimes it is necessary that the furrow made by the plough be further deepened by the spade, so as to form a channel sufficiently large; and wherever headlands intercept the run of water, channels must be cut through them to the ditch or outlet, so that none may stagnate upon the ground. Attention to these details, in practice, is essential in all cases of tillage; and it manifests a want of skill and industrious habits in a farmer to suffer his lands to be injured by the stagnating upon it of surface water.—*Low's Elements of Practical Agriculture.*

CHAPTER XXI.

Harrow—Oultivator—Roller.

The Harrow.—This instrument succeeds to the plough in the order of description and the uses to which it is applicable. It consists of a frame of wood or iron, in which a certain number of teeth are fixed, which are pressed into the ground by their own weight and that of the frame. The instrument is intended to pulverize the ground which has been acted upon by the plough, to disengage from it the roots and other substances which it may contain, and to cover the seeds of corn and other cultivated plants.

The harrow is greatly more simple in its form than the plough. It is even an imperfect machine in any form of which we can construct it; yet it is of great utility in tillage, and should receive all those mechanical improvements of which its nature will admit.

The harrow performing its operation by means of a certain number of teeth moved forward in the ground, and pressed downward by their own weight and that of the frame in which they are fixed, the first questions that occur, in investigating the principles of its construction, are the form that should be disposed in the surmounting frame. Were it the purpose, in harrowing, solely to drag up the roots of plants and other substances from the ground, the best form, perhaps, that could be given to the teeth would be that of a thin wedge, tapering to the point like the coulter of a plough, and, like it, inclining forward. But although this construction might be the best calculated for tearing up roots

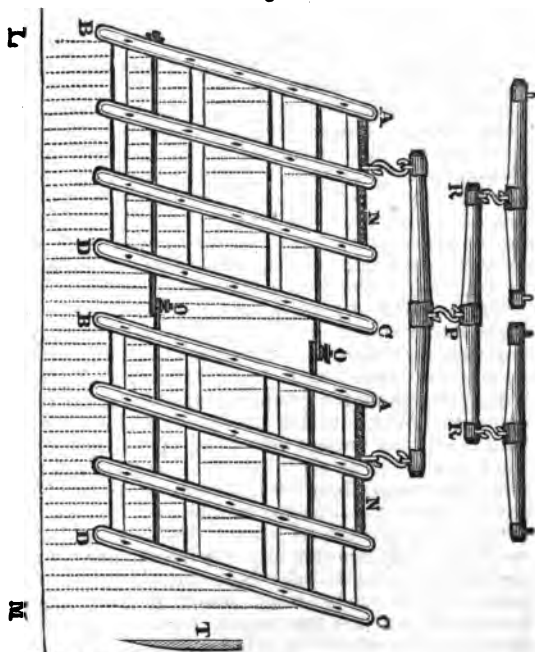
and other substances beneath the surface, it would not be so well fitted for covering the seeds and for breaking and pulverizing the ground, as when a broader surface was presented to the earth, and a greater movement given to its particles. The wedge for this purpose should be broad rather than thin. In order, therefore, to adapt the form of the teeth to this purpose—to the strength necessary to be given to them, and to the lateral or shaking motion to which they are subjected in passing over rough ground, as well as to their forward motion—it is conceived that the best form of them will be when their horizontal section is a square, whose diagonal is moved forward in the line of the harrow's motion; while they should gradually taper to a point, the forepart being kept straight, as in T, fig. 1.

With regard to the distribution of the teeth in the frame of the harrow, they should not be placed too closely together, for then they would be too much impeded by the obstacles opposed to them. Farther, they should be so disposed with relation to each other, as that one part of the instrument shall not be more interrupted than another. Again, their number should not be too great, because then their power to penetrate into the ground will be diminished, unless the weight of the whole instrument shall be increased in a corresponding degree. And, lastly, their length should not be greater than is necessary, because they will not on that account penetrate more deeply into the ground, unless the whole weight is also increased, and because this increase of length will give a greater power to the teeth, when encountered by obstacles, to split the frame in which they are fixed.

The harrows represented in Fig. 1,* of which the frame is of wood and the teeth of iron, are formed

These harrows are constructed by Mr. Craig, of Galway, and sold at \$15 the pair.

Fig. 1.



with a regard to these general principles. They are connected together in pairs by hinges. They consist each of four bars of wood, A B, C D, &c., which are joined together by an equal number of crossbars of smaller dimensions, mortised through them. The larger bars may be 2 1-2 inches in width or more by 3 in depth, and the smaller 2 1-4 inches in width by 1 in depth. The larger bars are placed oblique to the smaller bars and to the line of the harrow's motion, and the teeth are inserted into them at equal distances from each other. This inclination is made to be such, that perpendiculars from each of the teeth falling upon a line L M, drawn at right angles to the harrow's motion, shall divide the space between each bar into equal parts, so that the various teeth, when the instrument is moved forward, shall indent at equal distances the surface of the ground over which they pass.

The number of teeth in each harrow is 20, 5 being inserted in each of the larger bars. When two harrows, therefore, are employed together, the surface of the ground from L to M is indented by 40 teeth, impressing the ground at equal distances from each other, and covering the space of about 9 feet. The teeth may project below the under surface of the frame seven or eight inches, their length somewhat increasing from the hindmost to the foremost rows, where the oblique position of the line of draught tends most to elevate the harrow. The teeth are often inserted into the frame with a little inclination forward; but this deviation from the perpendicular, if made at all, should be very slight, because it renders the harrow more apt to be impeded by the weeds or other substances collected in the angle between them and the frame. The teeth are fixed in the bars by boring holes with an auger of about three fourths of an inch in diameter, and then driving them firmly through. The teeth, when thus driven into the bars, will be retained with

sufficient firmness. The best of the common kinds of wood for the larger bars, as being the least liable to split, is elm, birch, or ash, and for the crossbars ash.

The iron rods which terminate in the hinges O, O, may pass through the framework to give it strength. These rods keep the harrows at the distance required, and the hinges admit of either harrow rising or falling according to the inequalities of the surface. When thus joined, the harrows are drawn by two horses, guided by reins, the driver walking behind, so as to be prepared to lift up either harrow when choked by weeds or otherwise interrupted.

The method of attaching the animals of draught will be explained by the apparatus of swing-trees, shown in the figure, by means of which each animal must exert an equal force in pulling. There are plates of iron, N, N, passing through the left-hand bars of each harrow. These plates have a few holes in them, so that the line of draught may be shifted to the right or left, as may be required. The staple P upon the swing-tree R R, being the point to which the moving power of the harrow is attached, it is important to ascertain its proper position.

Were a perpendicular to be let fall from the staple P upon the line L M, the point of intersection would be in the middle of the entire breadth covered by the harrows, and an equal number of teeth would be on each side of the line of traction, and this would seem to indicate the position of the staple P. But the larger bars being placed oblique to the line of the harrow's motion, when any obstacle raised above the surface of the ground strikes one of these bars, it tends to press it to the right-hand side. And as there are eight bars of this kind, and these of considerable length, it will appear that, in ground where there is any great unevenness of surface, there will be a constant succession of strokes,

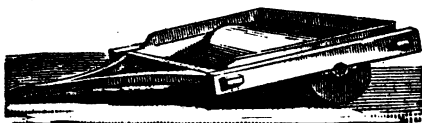
forming a strong lateral pressure on the left side of the several bars. But the staple P being nearly fixed in its position, while the harrows may be moved round, the effect of this lateral pressure is to turn the whole harrows on P, as a pivot, from left to right. In practice, accordingly, there is found to be a constant tendency in the harrows of this construction to swing around from left to right, and this often to so great a degree, in very rough ground, as to place the larger bars parallel to the line of motion, thus causing all the teeth in the same bar to follow in the same track. Hence the point P ought not to be precisely in the middle of the space covered by the harrows, but placed somewhat to the left hand, in order that so great a number of teeth may be placed on the right side of the line of traction, as to counteract the tendency of the harrows to turn from left to right. But farther, the position of T is not fixed, but must vary with the roughness of the surface over which the harrows are dragged. Hence not only must the staple P be placed somewhat to the left hand, but there must be the power of moving it more or less towards the left hand, according to the roughness of the surface passed over. This is effected by the iron plates, with holes, of which mention has been made, and by means of which the driver can readily shift the line of draught more or less to the left hand, as may be required.—*Low's Elements of Pract. Agriculture.*

The Cultivator, or Horse Hoe.—This is an instrument not as much known and used as it deserves and ought to be. It is adapted for operations between the plough and harrow, and at certain times is much better than either. It is half a plough, half harrow, and half hoe, and does all these operations conjointly. The first process, after corn has come up and is three or four inches high, is to use the common harrow upon it. This breaks the ground and partially clears it of the weeds or grass. It is

soon performed, and is very useful to the young plant. The next step has been to pass the plough twice through each furrow, throwing the ground from the corn to the centre of the furrow. Now this is the time to use the cultivator. It ought, after a few days, to follow the harrow, and is much more useful than the plough, as well as a great saving of labour. It cuts as deep and pulverizes the soil as well. It tears up and brings to the surface the roots of grass which the plough only covers, and by adapting the width of the cultivator to the space between the rows of corn, it half hoes the corn at the same time, and does the whole work most admirably. When there is much grass growing with the corn, it is an extremely useful instrument, as it pulls it up by the roots and in a great measure destroys it. For the Fiorin or Quack roots, with which our soil too much abounds, it will be of great service, and it appears to me it will be the most effectual remedy for it of any instrument we have yet tried. Corn is much sooner dressed with the hand-hoe, by the half ploughing, half hoeing operation of the cultivator. The cultivator is likewise very useful for the raising of potatoes, and for stirring the ground between the rows of turnips; and where a clover lay has been turned over to put down to wheat, when the plough cannot be again resorted to for fear of disturbing the sod, this instrument may be used for a shallow ploughing, which it will do much better than can by any other mode be effected. Corn is now raised with much less labour than formerly. It was the custom to hand-hoe a crop two, and often three times, and this was always an expensive and tedious process. Hoeing is now often omitted entirely, and is seldom done more than once; and still there are heavier crops of corn raised now than formerly. The process of high hilling is not only not necessary, but in a measure injurious, and our premium crops of corn have been raised with

little hoeing, and, of course, at the least expense. The idea that corn well grown will blow over by the high winds, without the ground is well raised at the foot of each hill, is erroneous. Providence has given to every plant sufficient roots and strength of stem to secure it against accidents of this kind, and we may aid the extension and multiplication of the roots best, and thus add to its security, if necessary, by stirring the ground, which will enable the roots to penetrate it readily in every direction. High hilling to potatoes is positively injurious. It not only turns away the rains from the plant, but, by raising a mound around them, prevents the sun and air from having that influence in aiding their growth and bearing which are both essential to the ensurance of a good crop.—*Dr. Beekman.*

The Roller is constructed of wood, stone, or cast iron, according to convenience, or the purposes for which it is used. In American husbandry, we have



yet no reason to expect, or perhaps desire, any but those made of wood, and such as any farmer, who has a moderate degree of mechanical skill, and the carpenter's tools which every farmer ought to keep, may readily construct himself. A good sound oak log, with the frame and shafts appended, makes a good roller. They are made of different lengths and sizes, varying from 15 to 30 inches in diameter. The lighter kinds are made in one piece; but the larger and heavier kinds are advantageously made in two pieces, with an iron rod passing through the centre of both, and upon which they revolve. English farmers construct the frame so as to rise above

the roller, upon which a box is fixed, either to contain stones to add to the pressure of the roller, or to receive small stones and rubbish, collected on the field while at work, which are to be carried off. Their shafts, when at work, are generally horizontal. We think the roller is more easily drawn when the draught is on a right line from the collar or yoke of the team to the point of resistance. This may be done, and the advantages of the box retained.

The uses and advantages of the roller are many and important, and no farmer should be without one. They are particularly important in the seeding process, to break down the clods, pulverize and smooth the surface, and to press the earth to the smaller seeds, which otherwise often fail to germinate for lack of moisture. This is particularly the case with oats, barley, and the grass seeds. In autumn the roller is sometimes passed over winter grain, with a view to counteract the effects of frost the following winter. In spring it is advantageously passed over winter grain, as soon as the ground is so solid and dry that the feet of the cattle will not poach the surface. It renders light ground more compact; presses the soil to the roots of the grain, and thus promotes their growth; and upon all soils closes the innumerable cracks and fissures which abound on the appearance of dry weather in spring, and, by partially burying the crown, causes grain to tiller better, that is, send up more seed-stalks. Finally, the roller is of great advantage to grass grounds in the spring, by reducing inequalities of surface, and pressing down the plants or earth which have been thrown up by the frost.

There are also rollers for other purposes, viz., the *spiked roller*, which is used for pulverizing stiff soils preparatory for wheat. This is formed by inserting several rows of spikes, or cast or wrought iron darts, in a common hardwood roller. The *concave* or *scalloped roller* is adapted to the form of ridges, and is often attached to the turnip-drill.

CHAPTER XXII.

Draining.

PRINCIPLES to be ever kept in mind by the tillage-farmer are to keep his land dry, rich, and clean. The first in the order of these principles, and an essential one to be regarded in cold and humid countries, is to keep the land dry.

While a certain portion of water is essential to vegetation, an excess of it may prove greatly injurious. In the colder countries, an excess of water is one of the main causes of infertility, and a primary object of the husbandman there is to carry it away from the ground.

The water which falls from the atmosphere does not sink to an indefinite depth, or to a great depth in the earth. It is easier retained at or near the surface where it falls, and whence it is evaporated, or it finds its way to a lower level, by channels upon the surface, or in chinks of rocks, or beds of gravel, sand, and other permeable substances beneath the surface.

The purpose in draining is, when water stagnates at or near the surface, or when, having penetrated to pervious substances below the surface, it is finding its way to a lower level, to confine it to a determinate channel, and to carry it away by some convenient outlet, in order that it may not overflow or saturate the soil.

The substances through which water finds its way with facility are the looser earths, sands, and gravels, the crevices of rocks, and beds of loose or decomposing stones : the substances which resist its progress are clays and the harder rocks.

When the soil rests on a retentive subsoil, whether of clay or pervious rock, it forms a species of reservoir for water, absorbing and retaining it. The object of the drainer, in such a case, is to give egress to the water in fixed channels or drains. This is partly effected by the common ditches of the farm, partly by the open furrows of ridges already described; and, when these are insufficient, by cutting trenches in the hollows, or where best suited to effect the purpose. These trenches are either left open, or they are filled to a certain depth with small stones or other substances, through which the water may percolate; and then they are covered again with earth and soil, so that the plough may pass over them in tillage.

When water overspreads the surface or is absorbed by the soil and is unable to penetrate to the looser strata below, the carrying it away in channels is termed *surface-draining*. When it has already penetrated into the earth, and is contained in reservoirs there, or is finding its way to a lower level through permeable substances below the surface, the confining it to a fixed channel is generally termed *under-draining*. These two purposes of the drainer are constantly combined in practice, but yet they are in some degree distinct. It is the intercepting of water below the surface that constitutes the most difficult part of draining, and which requires the application of principles which it is not necessary to apply in the case of surface-draining.

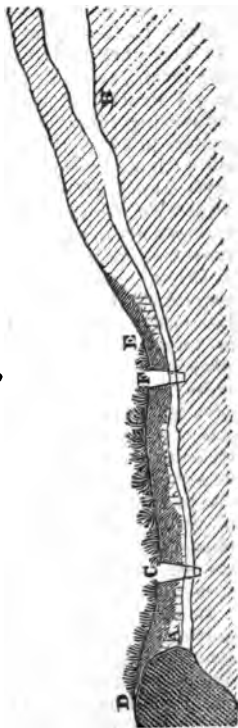
If we shall penetrate a little way into the looser portion of the earth, we shall generally find minute stratification, consisting of gravel, sand, or clay, of different degrees of density. These strata are frequently horizontal, frequently they follow nearly the inclination of the surface, and frequently they are broken and irregular. Sometimes the stratum is very thin, as a few inches in thickness, and sometimes it is several feet thick; and sometimes the

traces of stratification disappear, and we find only, to a great depth, a large mass of clay or other homogeneous substances.

Fig. 1.



Fig. 2.



When these substances are of a clayey nature, water finds its way through them with difficulty; when they are of a looser texture, water perco-

lates through them freely. These, accordingly, form the natural conduits or channels for the water which is below the surface, when finding its way from a higher to a lower level.

When any bed or stratum of this kind, in which water is percolating, crops out to the surface, the water which it contains will flow out and form a burst or spring, oozing over and saturating the ground, as in the foregoing figure 1, which represents a section of the ground from C to D.

When water is, in like manner, percolating through one of these pervious strata, and meets any obstruction, as a rock or bed of clay at A, Fig. 2, it is stopped in its progress, and by the pressure of water from a higher source, it is forced upward, and thus saturates the superjacent soil, as from D to E, forming springs or a general oozing.

In either of these cases, and they are the most frequent that occur in practice, the object of the drafter is to reach the water in its subterraneous channel before it shall arrive at the surface, and to carry it away in a drain.

By cutting a drain at A, Fig. 1, the water of the stratum of sand C E, is cut off before it reaches the surface at C, where it forms the swamp C D.

In like manner, in Fig. 2, by forming a drain at C or F, the water is cut off in its channel A B, and thus, in relieving the pressure from the higher source, by giving egress to the water through the drain, the cause of the wetness from E to D is removed.

In looking at the sloping surface of any tract of ground, as a field, in which there is an oozing or bursting out of water, we shall generally distinguish the line where the wetness begins to appear on the surface extending over a considerable space, *x x x x x*, Fig. 3, the effects appearing in the wetness of the ground farther down the slope, as *y y y*. The line where the wetness begins, and which is generally rendered perceptible by the change of colour of the soil, the

Fig. 3.

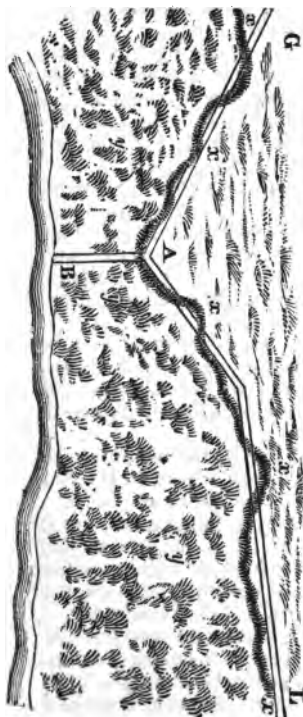
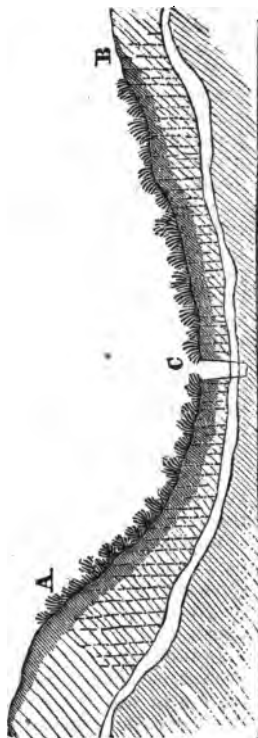


Fig. 4.



tendency to produce subaquatic plants, and other indications of wetness, marks for the most part nearly the course which the line of the drain should follow. By cutting a drain nearly in this line, as

from G to A and from L to A, sufficiently deep to reach the porous stratum in which the water percolates, we shall intercept it before it reaches the surface, and by carrying it away in some convenient outlet, A B, remove the cause of wetness.

This accordingly forms, in the greater number of cases, the rule adopted in practice for the laying out of drains upon the surface; the line is drawn nearly at, or a little above, the line of wetness, or, to use the common expression, between the wet and the dry.

Should the line of drain be drawn too much below the line of wetness, as at G, Fig. 1, then the trench would fail to intercept the water; and farther, if it were filled with earth, stones, and other substances, in the way to be afterward described, the whole or a part of the water, would pass over it, and the injury be unremoved.

Again, should the line be too much above the line of wetness, as at H, the drain would fail to reach the channel of the water, and so would be useless.

It is for this reason that, in common practice, the rule is, to draw the line of the drain nearly between the wet and the dry, or a little above it, taking care to give it the necessary descent, and to form it of sufficient depth to reach the pervious bed or stratum in which the water is contained.

But as water may arrive at the surface in different ways, and the wetness be produced by different causes, so variations from this rule of lining out the drain may be required, and the judgment of the drainer is to be shown in adapting the course of his drain to the change of circumstance.

Sometimes, in a hollow piece of ground, feeders may reach the descent, as in Fig. 4; and the water may be forced upward by the pressure from each side of the hollow, and thus form the swamp from A to B. It may not be necessary here to cut a trench on each side along the line of wetness at A

and B; a single trench C, cut in the hollow, and giving egress to the water, may relieve the pressure and remove the swamp.

Fig. 5.

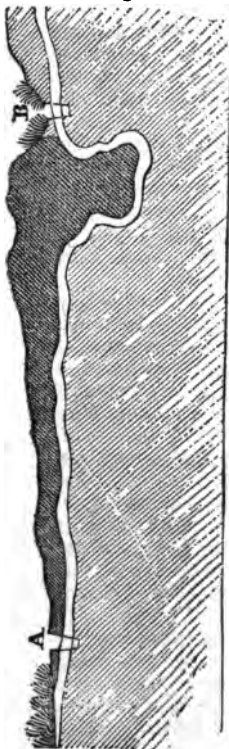
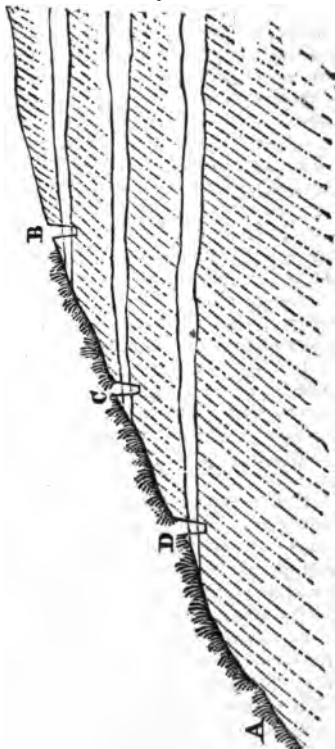


Fig. 6.



Sometimes, upon a sloping surface, one pervious stratum, in which water percolates, may produce more than one line of springs, as B and A, in Fig. 5. Here a single drain cut at B will remove the cause of wetness at both swamps, without the necessity of the drain at A.

And, in practice, it is well to wait to mark the effect of a drain cut in the higher part of the slope to be drained, for these effects often extend farther than might be anticipated, removing springs, bursts, or oozings at a great distance.

On the other hand, a single swamp, as from B to A, in the fig. 6, may be produced, and yet one drain at B may be insufficient to remove it. In this case, the water being brought to the surface by more than one channel, it is necessary to form several drains to reach the several beds in which the water is contained, as at B, C, and D.

These examples will show that one rule, with respect to the laying out of drains, is not applicable to all cases, but that the drainer should adapt his remedy as much as possible to the cause of injury. One object, however, to be aimed at in all cases of under-draining, is to reach the bed, channel, or reservoir in which the water is contained.

Before beginning to drain a field or tract of ground, it is frequently well to ascertain, by examination, the nature of the substances to be dug through.

At the upper part where the wet tract to be drained appears, or between the wet and the dry, let a few pits be dug. The place of each pit is to be marked out nearly in the direction of the proposed line of drain, six feet long by three in width, in which space one man, and, if required, two, can work. Let the earth be thrown out to the lower side, and to such a distance from the edge of the pit as not to press upon and break down the sides. Let these pits be cast out to the depth of five or six feet, or more, if necessary, so that we may reach, if

possible, the porous bed in which the water is contained. Should we find no water, then let us apply to the boring-rod, in order to ascertain at what depth the porous substance lies in which the water is contained.

Sometimes water will not be found until we come to a great depth. It may be so deep that we cannot reach it by any drain, or even by boring with the auger. In this case we are saved the labour of making the drain unnecessarily deep. Sometimes we shall proceed to a considerable depth without finding any appearance of water, when all at once, by breaking through some thin stratum, we shall reach it. The water is frequently seen, in this case, to boil up like a fountain, and this affords the assurance that we shall succeed in our object.

This species of preparatory examination by means of pits is, therefore, in many cases useful. It affords the means of judging of the proper depth and dimensions of which the drain shall be formed; it prevents the committing of errors in the laying out of the lines of drains; and it enables the drainer to enter into contracts with his workmen with precision.

When we have thus, by sinking pits in various parts of our intended lines, obtained an idea of the nature of the ground, of the substances to be dug through, and of the depth of the water, we mark our lines of drains upon the ground.

This may be done by pins, or by a plough drawing a furrow along the intended line.

It is at this time very convenient to make a hand-sketch of the piece of ground to be drained, marking each line as it is laid off in the field, and noting the depth and direction in which the water is to run.

The lines being marked off in the manner described, these are to form the upper edges of the drains.

The width of the drain at the top depends upon its depth, it being usual, except in the case of very hard and tenacious substances, to make it slope from the top to the bottom. Thus, if it be six feet deep, and from 18 inches to two feet wide at the bottom, it may be two and a half feet wide at top.

The workman, in forming the trench, works up to the higher ground, and never from the higher ground to the lower. The instruments which he uses in the operation are the common spade, a shovel for throwing out loose substances, a pick or mattock for raising stones and breaking the earth when hard, and the footpick.

The materials to be used for filling the drain may be stones, tiles, or other hard and durable substances. When stones are to be employed, if they are inconveniently large, they may be broken to the weight of three or four pounds. They may be laid down for use, before the cutting of the drain is begun, along the upper line of the drain, the earth being thrown by the workmen to the lower side; or else they may be brought forward while the work is going on, and thrown from the cart into the drain.

In the larger class of drains it is regarded as beneficial, and even necessary, to form a conduit at the bottom. This is done by building a little wall roughly on each side at the bottom, about six inches in height, and so as to leave an aperture or conduit of about six inches in width. The workman then covers it with such flat stones as he can procure, filling up also the interstices of these covers with small stones, so as to defend the conduit from earth and other substances that might fall into it. When this is done, the remaining stones are thrown in promiscuously, to the height of 18 inches or two feet above the cover. The stones are then to be made level at the top, and either covered with the sod which, on breaking the ground of the drain,

had been laid aside for that purpose, or with a covering of straw, heath, or the like. The object of this covering is to prevent the loose earth from falling among the stones.

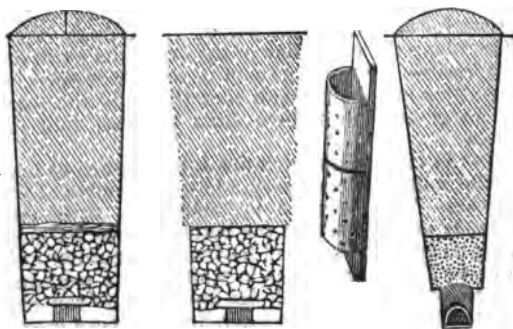
When these operations are completed, the earth which had been thrown out of the trench is shovelled upon the stones until it be above the level of the surface. The object of raising it higher than the surface is to provide for the subsidence of the loose earth, which is generally found to be rendered more compact, and to occupy a smaller space than it did in its original state. When a portion of the earth is shovelled, it is an economy of labour to employ a common plough for filling in the remainder.

Fig. 1.

Fig. 2.

Fig. 3.

Fig. 4.



A drain thus formed will appear on a transverse section, as in fig. 1, and after the subsidence of the earth, as in fig. 2. Where the soil is very soft, it is of benefit to pave the lower part of the drain with stones or slates. In the whole operation of forming the trench and conduit, great care is necessary

in seeing that all the parts of the work are executed well.

The stones used for this species of drain may be sandstone, or any of the harder stones that can be obtained. But in many cases stones are not to be obtained, in which case tile may be substituted.

The tiles, which are made with an arch, as in fig. 3, may be formed of separate pieces, of about 14 inches in length. Flat soles are made of the same materials, on which the arched tiles are to rest.

The method of forming the drain, when tiles are the material employed, is somewhat different from that adopted when stones are used.

The drain is carried down as narrow as a man can work, and at the bottom an excavation is made by means of a narrow-mouthed spade to fit the dimensions of the tile, which is then placed upon its stand or sole. Above this should be laid some loose materials, as clean gravel or sand, for allowing the filtration of the water. Even brushwood and such materials may be used; for, though they are not of great durability, they serve the purpose, even after they have decayed, of rendering the earth more open and pervious to water.

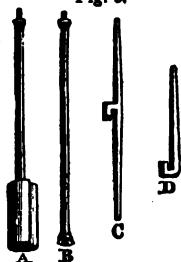
Drains formed in this manner, whether the material employed be stone or tile, will be found efficient when they are laid out in the proper direction, and when the pervious substances are reached in which the water is contained.

But it is often impracticable to reach these substances with a drain of common depth. In this case, apertures may be formed at the bottom of the drain by boring or sinking down at the proper distances, until the pervious beds in which the water is contained are reached. By this means the water will be allowed to flow up from below into the cavity of the drain, and so will be carried away.

The application of this principle had been famil-

lar from the remotest times in the sinking of wells. But it was not till after the middle of the last century that the same principle was applied to the draining of land. This was done by Mr. Elkington, of Warwickshire, who employed the auger and the boring-rod for the purpose of reaching the channels and reservoirs below the surface, when an ordinary drain could not reach them.

Fig. 5.



The auger employed for this purpose is similar to a carpenter's wimble. It may be from four to five inches in diameter. Square iron rods are made to be screwed into each other, so that the length of the line of rods may be increased in proportion as the auger penetrates the ground. In the annexed figure, A is the auger, B one of the rods, C a key for turning it round and working

it, D another key for holding the rods when they are to be unscrewed by means of the key C.

This instrument may be frequently found useful when the channels and reservoirs of water can be reached in this manner. The apertures are formed by the auger in the bottom of the drain. When the water is reached, it will spring up into the drain in the same manner as water in the bottom of a well. It is not necessary to employ any artificial means for keeping the apertures open, as the flow of the water will suffice to maintain for itself a passage.

Sometimes, in place of an auger hole, wells are sunk at intervals along the side of the drain, and filled with stones in the manner shown in the figure.

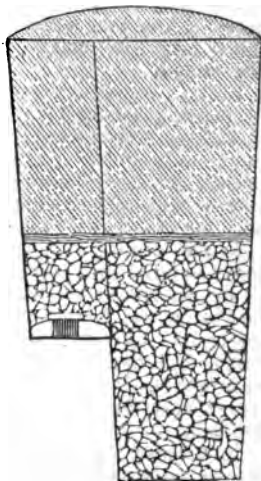
In all cases of under-draining, the drains should be made of sufficient dimensions. They should not be less than four feet deep, even when the pervious

strata lie at less depth; and the reason is, that they may be more permanent and better defended from mud and sand carried down by surface water. It is not necessary that they be made deeper than four feet, when that is found to be sufficient; but they must be carried, if necessary, to the depth of 6 feet, or even sometimes of 7 feet, though the expense and difficulty of executing the work increase in a great proportion as the dimensions of the drain increase.

The importance, in this species of draining, of proceeding upon principles in laying out the lines of drains, instead of acting at random, as so many do, cannot be too strongly impressed upon the attention of the drainer. Every drain, however rudely devised and imperfectly executed, may do some good. But one drain well laid out, and of the required dimensions, may perform a purpose which no multiplication of minor and insufficient drains can effect. These may lessen the effects of wetness, but the other is designed to remove the causes of it; and the more perfect practice will usually be found in the end to be the most economical as well as the most efficient.

The drains of the larger class described, it will be seen, are intended solely for the removal of water which is contained in reservoirs and channels below

Fig. 6.



the surface. They do not supersede the necessity of carrying away water which is at or near the surface. From this latter cause, an equal or greater injury may arise, and must be met by a corresponding remedy.

Surface water may be carried away either in open drains or in covered trenches.

The open drains are the ditches of fields, which ought to be so laid out as to favour the descent of water; the open furrows which are formed by the ridges; and open trenches cut in the places necessary for allowing a passage for the water.

In the forming of open trenches, the dimensions must be fixed with relation to the quantity of water to be carried away, and the direction determined by the natural flow of the water, or by the particular course by which it is expedient to carry it off. In general, open drains are formed in the hollows or lower parts of the land to be drained, so that the water may find access to them from the higher grounds.

In forming open drains of whatever depth, the sides should possess a declivity from the bottom to the top, to prevent them from crumbling down and being undermined. Except in the case of rock, this inclination should not be less than 45° ; and when the earth is soft, and the flow of water considerable, it should exceed 45° . In all cases, the earth should be spread from the edge of the trench backward, so that the water from the lands on each side may have access to it.

The next class of surface drains consists of covered trenches. These are formed in the same manner as the larger drains already described, with this difference, that no conduit is required, and that they need not be of the same depth and capacity. They may generally consist of a small trench, from 2 1-2 to 3 feet deep, filled with stones or other loose materials to within a foot of the surface, so that there may be a sufficient passage for the plough above.

These drains are generally carried through hollow places where the water may stagnate, or obliquely along the line of descent, and sometimes in regular lines along the surface of flat lands.

When the soil rests on a subsoil of considerable depth, the water that falls upon the surface is unable to penetrate freely down, and is absorbed and retained by the soil and upper part of the subsoil. The object in such a case is to give a ready egress to the water with which the soil is saturated, which will be done by forming for it various channels towards some convenient outlet. A good arrangement of ridges and furrows will sometimes of itself effect this purpose; but as the water constantly tends to sink below the level of the furrows, drains may become necessary to assist in carrying it away.

A system of draining having relation to this condition of the soil and subsoil, has been termed the Essex system, from its having been extensively practised in that flat and clayey district. This system consists in running small drains parallel to each other in every furrow or alternate furrow. The object of this species of draining is not to intercept springs flowing in channels and pervious strata below the surface, but to carry away that water from the surface which, from the tenacity of the soil and subsoil, cannot find its way downward.

The best materials to be used in this species of draining is tiles, formed into a semicylinder or arch, and resting upon a flat sole, fig. 3. The diameter of the semicylinder may be from three to four inches. The tiles are to be placed on their stands in the bottom of the trench. The water finds its way into the arched conduit thus formed at the crevices formed by the junction of the tiles. Sometimes, in addition, are formed through them small holes, so that the water may more readily find its way into the conduit.

The trench for the reception of the tiles may be from 18 inches to two feet deep. The tiles may be covered, first with the sod inverted, when there is any sod upon the surface at the time of draining, second with the looser soil next the surface, and lastly with the more tenacious subsoil. But it is always an improvement in the case of this kind of drains to lay over the tiles some gravel, sand, or other pervious matter, before shovelling in the earth.

Drains of this kind, when properly made, and when the tiles are good, will last for a considerable time. When choked at any particular part, they can be easily taken up at that part, and the tiles replaced or new ones substituted.

Though this species of draining is well suited to particular cases, great care should be taken that it is not applied under circumstances to which it is not suited. When employed where under-draining is the proper remedy, it is neither so durable nor efficient as the system of larger drains, formed upon correct principles.

Thorns, brushwood, and branches are frequently employed in the filling of drains. They serve the purpose of affording a more pervious channel to water, but they soon decay, and the drains are very apt to be choked. Sometimes, indeed, the channels formed by the water remain, where there is a considerable current, long after these materials have decayed. But this cannot be depended upon; and such materials, therefore, ought not to be used, if better can be obtained.

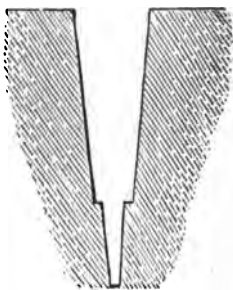
Sometimes a species of draining, termed wedge-draining, has been employed. The general method of performing this is to form a narrow trench with a long narrow shovel. The spit being taken out as deep as the shovel can go, a scoop is employed to clear out the mud and loose earth at the bottom. Then another shovel corresponding with the first is used, and a second spit taken out, and then a

narrower shovel still to clear the whole out; forming a trench with a ledge, as in fig. 7.

A piece of sod, with the grass side below, is then forced down, and, resting upon the ledge, a space is left for the water below. Sometimes the ledge is dispensed with, and the sod is merely formed into a wedge, narrowed towards the grassy side, and this, when the little trench is cleared out, is pressed into it and covered with earth; and as it does not reach the narrow bottom, a channel remains below, through which the water percolates.*

This simple species of drain has been extensively adopted in some districts; and as it is easily formed, and as the number of drains may be multiplied at little expense, considerable benefit has resulted

Fig. 7.



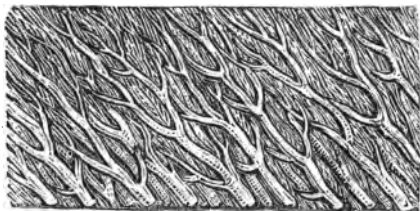
* There are two other materials for under-draining which we have employed for want of stones, both equal, if not superior, to sod, viz., brushwood and straw. For brushwood the trench may be made like fig. 1, 18 or 24 inches wide, and three or four feet deep. The brush we have used have been pine saplings, from two to six inches at the butt. They are cut into lengths of four or five feet, and, commencing at the upper end, placed diagonally in the trench, the butts down and towards the outlet. When completed, the ditch is apparently full. The brush is then all brought within the edges of the ditch, well trod down, and the earth thrown in. Bundles of fagots are sometimes employed. When straw is to be used, the ditch is made to conform to fig. 7. The lower part is cut by a spade ten inches long, three broad at top, and one inch at bottom, and the loose dirt carefully removed with a scraper, which we may hereafter give a figure of; the straw, being twisted into ropes, is then pressed gently with a spade into the narrow cut, the sod placed over it, and the earth thrown in. A side view of a brush drain is shown in the annexed cuts; A shows the form of placing the brush, and B its position after the trench is filled with the

from the use of it. But although drains of this kind will remain open for a considerable time, yet they are exceedingly apt to be closed up, on which account the use of tile is in most cases to be preferred.—*Low's Elements of Practical Agriculture.*

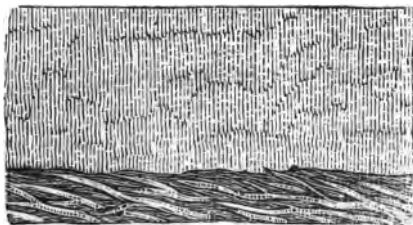
Importance of Draining.—It is necessary, for the perfection of most crops, that they should enjoy all the benefit of our summer heats. When a soil is saturated with spring water, though water does not appear on the surface, the roots of the crop which grow upon it penetrate the wet part, which may be supposed to possess a temperature never above 60 degrees. The crop, consequently, fails for want of

earth. In both cases the sides of the main trench may be cut perpendicular.—*Cond. Cult.*

A.



B.



the necessary heat in the soil. Decomposition of vegetable matter, the food of the crop, is also seriously retarded by this cold temperature. Stagnant waters are as unhealthy to cultivated crops as they are to animals. We have now in our mind an extensive inclined plane which we examined last summer, of more than half a mile slope, embracing 70 or 80 acres, and possessing a rich soil, one fifth of which was rendered unfit for tillage or the finer grasses, in consequence of springs which burst forth near the top of the plane, the waters of which passed down its whole extent, and principally in the soil, in gentle depressions or hollows. We are confident the evil here might be remedied at a slight expense, which would be remunerated in a single season by draining. Grounds habitually wet, either from springs or water stagnating in the soil, for want of declivity of drains to carry it off, will not produce good crops. Draining is an effectual cure for the evil. Open drains will alone answer to carry off surface water, and in situations where much water may occasionally pass. These should hardly ever be less than three feet broad at surface, and two feet deep; the sides sloping so as to leave the bottom eight to twelve inches broad. A greater depth and breadth are often requisite. Long experience has convinced us that good drains in the end are always the cheapest drains, and that, when they are well constructed, they constitute one of the most profitable improvements of the farm. But we consider under-drains in soils which are habitually wet, cheaper, better, and more profitable to the proprietor, either to carry off stagnant water from flat surfaces, or to arrest that proceeding from springs, than open drains. They are more efficient, because they generally lie deeper, and are not so liable to be choked up. They are more economical, because they seldom, if well made, require repairs, and do not waste any land. They are beneficial on all flat

surfaces which have a retentive subsoil, and upon all slopes rendered wet by springs. They are wanted wherever water at midsummer rests upon the subsoil, or saturates the soil within the reach of the roots of cultivated crops. We do not here mean to discuss the principles or describe the mode of draining, as we have published much upon this subject, and design to publish more, with such pictorial illustrations as shall serve to render the subject perfectly familiar to the readers of the *Cultivator*. A very simple means of determining whether a field is likely to be benefited by under-draining is, in June or July, to dig a hole like a posthole, say two feet deep, and the presence of water at the bottom, and the height to which it rises, will at once decide whether the land is to be benefited, and to what extent, by under-draining. Draining effectually is almost an untried experiment with us. We are not familiar with the process, and startle at the expense: yet if we compare the cost with the advantages which will accrue for a succession of years, we shall find the operation to be a very economical one.

Well drained grounds may be sown or planted ten to fifteen days earlier in spring than those which want draining, and the crops are much less liable to be injured by heavy rains.—*Ed. Cultivator*.

CHAPTER XXIII.

Pattern Farm of Baron Von Voght.

WE find in one of our recent foreign agricultural periodicals, the *British Farmers' Magazine*, some account of the successful experiments in husbandry of this distinguished German, highly worthy of no-

tice. We give an outline of his practice, under the persuasion that it will be found interesting and useful to the readers of the Cultivator.

In 1813, the baron undertook to improve the condition of an estate denominated Flottbeck, as a pattern farm, and to make it an experimental farm for the north of Germany. In 1829, he had carried his improvements to so high a state of excellence, that he published, for the benefit of the visitors who thronged to see him, a pamphlet, developing the principles, by the adoption of which, his soil, naturally bad, had been raised to a state of high productiveness. It is from a portion of this pamphlet, for we have not seen the whole of it, that we collate the following facts.

The soil of Flottbeck is a mixture of sand and clay. Its original depth of *krume* (mould) was only 3 inches; the surface was uneven, and the soil wet, water standing for a long time, and manure ineffectual on account of the consequent low temperature. Fields could not be sown owing to quagmires, often till June. The winter crops were full of tares and perennial rooted weeds; summer crops abounded in wild radish and mustard; the clover with wild chamomile, sorrel, &c.; and the fields with dog's grass and other noxious plants. How many of our farms now form a counterpart to this description of Flottbeck?

The means of improving which the baron instituted to raise the condition and increase the fertility of his farm, consisted principally in

1. Levelling the surface and thorough drainage.
2. Deepening the *krume* or soil at least one inch a year, till he had gained a depth of 14 inches, this depth being requisite, in his opinion, for the roots of plants to penetrate, and as a reservoir for moisture, to supply the crop in time of dry weather. To obtain this depth, trench-ploughing (*rayoli*) was resorted to when necessary.

3. Increasing the fertility with the increasing depth of the soil, by ploughing in green crops, and by husbanding and judiciously applying manures, the latter applied to the potato and rape crops, and before it had become exhausted by fermentation.

4. Throwing the land into one-bout ridges in autumn (it being generally flat and rather stiff), and cleaning the intermediate furrows with a double mouldboard plough. This operation enriched the soil by atmospheric influence, broke down its stubbornness, and laid it dry, so that the spring operations could be commenced two or three weeks earlier than formerly.

5. Thorough pulverization preparatory to putting in seed, and giving these only a superficial covering of earth.

6. Graduating, by a scale which the baron's long observation and numerous experiments had enabled him to contrive, the manure to be applied to the precise demands of the soil and crop; thus receiving the whole benefit which it was capable of imparting, without loss by excess.

7. A judicious rotation, in which green crops often intervened. The rotation was one of six years, as the clover, which he observes forms the basis of agriculture, cannot return oftener. The intermediate crops were wheat, oats, mixed fodder, barley, rye, potatoes, vetches, rape, &c., the climate of Germany not admitting of the culture of Indian corn.

In 1829 Flottbeck exhibited a far different appearance from what it did in 1813. All the fields showed a level surface; the krume or mould had everywhere a depth of 14 inches. The fields rendered dry by ditches, and under water carried off by 27 under drains; no noxious plants, infesting the ground, save the dog's grass, when the clover happened to be frozen out, and the produce so much increased as that the same area which, in 1813, would yield

only 14 bushels rye, in 1829 was found to produce 24 bushels of wheat.

We think there is much in Baron Von Voght's practice that commends itself to the notice of our farmers. The means which he employed are within our reach, and the advantages of using them manifest. The climate of Germany is not very dissimilar to ours, save that ours is rather the most mild. That the readers of the Cultivator may understand the principles upon which the improvements at Flottbeck were based, we subjoin them in the baron's own words.

"The few general principles adopted here, with all kinds of produce, are the fruit of thirteen years' experience, and several thousand experiments.

"1. The soil must have 11.280 to 14.100 inches of krume, in order to admit of the roots penetrating into the ground; that in wet weather the water, which in a flat soil might drown the crops, may be absorbed, and formed in the deep into a reservoir, from which the extremities of the roots may imbibe a nourishing moisture, impregnated with carbonic gas, which it draws from the manure fermenting in the earth.*

"The krume must have a depth of 14.100 inches, in order that the exhausted surface, being buried at a greater depth, may reimbibe the lost moisture.

"This I obtained by having the land ploughed in autumn, at a depth of about 5.640 to 7.520 inches, then having it finely harrowed, and finally rayolt it with two ploughs, one behind the other (the last with four animals). This requires, of course, swing

* "Thaer mentions the following proportion of the value of the soil, with a flat and deep mould. "If," says he, "the soil, with a mould of 3 inches, is worth 38, that possessed of 5 inches of mould will be worth 50; that of 8, 62; and that of 11, 74;" and this entirely agrees with my experience at Flottbeck. Should we then hesitate to spend a few years and some manure thus permanently to enhance the value of our field?"

ploughs, as it is absolutely necessary to plough before rayoled.

"The latter operation is usually performed by oxen.

"2. In autumn all ditches must be opened, and all the drains examined, so that the water may not be stopped in any place.

"3. All rayolt land must be laid in high furrows, by means of ploughing, always two furrows together, after the rayoled and furrowing, so as to make a water furrow at every 16.920 inches, which is deepened and cleaned by means of double struck-butt (boards fixed to the plough). With a clayey soil this operation is *indispensable*.

"The advantage of this mode of treatment is, that it keeps the soil dry, and renders it capable of being cultivated three weeks sooner than other shallow land; that it avoids stiffness, and, on the contrary, the high ridges being frozen through in winter, are found very mellow in the spring. I cannot deny that in autumn this requires four kinds of ploughs (the last two of which may certainly be considered as only half kinds of ploughs), instead of one kind generally used on large farms. Moreover, this depth of mould cannot be obtained in less than ten years; when, at the same time, the disadvantage of an inferior subsoil can be repaired by manure, which will add about one inch of mould a year, a method quite impossible on large farms, and on small ones attainable only by a proprietor, and never by a farmer.*

"These high furrows are separated in spring with the four-horse split-plough; if the land is quite clean, it may, after being harrowed in the manner which will be mentioned hereafter, be immediately sown; but if it is not, it is hooked crosswise.

* The term farmer is applied here only to those who hire farms, and not to those who cultivate their own lands, as is generally the case in the United States.

"4. All the land which is not rayolt, because there remains from the preceding harvest too much manure on the surface, which, *if the next crop should want it*, must not be removed too far, is, if it bears no manure crop, ploughed in autumn, first shallow, then deep, and, lastly, laid in high furrows. In spring, in which there is as little ploughing as possible, it is, after the splitting, according to the necessity of the crop and soil, first harrowed, and then hooked crosswise, or only harrowed in the manner prescribed.

"5. It is a principal maxim to sow a green crop for ploughing in, in the rapeseed-stubble as well as in the corn-stubble, where no clover has been sown. In August, I use for this purpose rapeseed; in the beginning of September, turnips; from the middle of September to the middle of October, rye; then there is but one ploughing in autumn, a method which I recommend on large farms.

"The manure crop is in the spring shallowly rayoled in, and is equal in its effects from 3.914 to 5.811 loads of manure per acre.

"6. One observation, which leads to the most important results, was the certain conviction that it is the vital power of plants which, by the incomprehensible faculty of decomposition and assimilation, by means of their leaves and stalks, constantly imbibe an incredible quantity of substances, in the shape of gases and manures, and convert them into their own elements, rejecting what they do not want, changing what they have received into a new body, and so continuing till they have formed their blossoms; that the root, which till then keeps growing and oozing out moisture, only begins, when its growth is perfected, powerfully to decompose that which surrounds it, and alone supports the fruit, while the leaves and stalks are fading; that the vital point of the plant has its seat exactly in the centre of the germe, from which it forces the root

into the earth, and the stalk upward; that everything depends, in the first growth of the plant, on keeping this point in health and activity; that this should be done in sowing.

"1. When the surface is as much as possible pulverized, in order that the seed-corn or potato-shoot be surrounded by, or rather laid on earth finely divided, in which the fibres of the root may quickly shoot, and where air, moisture, and warmth may operate with facility.

"2. When the shoot, lying on such a pulverized surface, being covered only a couple of lines, in order that light, air, warmth, dew, and other atmospheric moistures may immediately excite the vitality in this point, and thereby promote the development of the germe, and procure nourishment to the first leaf.

"I refer, with regard to this, especially to the specimens of dried plants kept ready for the inspection of the visitors, which so strikingly show what difference there is in the vital germe lying on the surface, where roots and leaves immediately, numerously, and powerfully shoot from one point, and the weakened vital germe, which, lying at a depth of 1.680 inches, shoots forth few roots, but a white thin tube, which rises as far as the surface, where the knot is formed, whence the weakened germe pushes forth a single and sickly plant.

"The result of this observation was, that we took every possible pains to give to the surface a depth of from 1.880 to 2.820 inches, the necessary state of pulverization, to divide the thickly-sown seed equally upon it, and to give it as thin a covering of the pulverized soil as possible. But for this we were entirely without implements.

"The grubber, indeed, gave looseness to the surface, but did not destroy the small clods. The roller pressed the soil too firmly, and if it happened to rain, a fresh process became necessary. The

usual harrow, with teeth 6.580 inches apart, drew, even in a ground previously harrowed, lines in which the seed sown by the best sower would fall, and then stand too thickly, while a surface of 2.820 inches was left between these lines, which contained few plants, but became a nursery for weeds.

"Then it occurred to us (after the grubbing and usual harrowing) to pass with the iron Mecklenburgh harrow reversed, the upper side of it being flat upon the surface, till all the small clods were pressed into a powder. Then I had harrows made, the teeth of which are only from 1.410 to 1.880 inches apart, and in the Flemish fashion, placed in a slanting angle. With these we passed sharply over this finely-pressed soil, with the horse fastened in the middle, and afterward in one corner, after which we sowed. The corn came to lie in lines 1.410 apart, and was harrowed in crosswise, with the *drag* teeth of the close harrow;* and, by this means, the seed was but slightly covered, and not a grain displaced.

"By this mode of cultivation it was found that every germe immediately shot forth strong roots and several stems at once; and an experience of several years has shown an increase of produce of from 20 to 30 per cent. occasioned by it, as we continued to cultivate a piece of ground next to it in the usual manner.

"7. I must farther mention as the last, but not the less important principle and cause of success, that each of the manured fields has been brought to that point of fertility in which it can yield the greatest produce; so that, with less manure, it would not yield its full produce, and more manure would cause the crops to lie down, even if the year were not wet. The difficulty of being able to fix

* With the teeth slanting forward. They are called *drags* when the teeth slant backward.